

* * * * * STN Columbus * * * * *

FILE 'HOME' ENTERED AT 15:10:14 ON 06 MAR 2009

=>

=> file registry

COST IN U.S. DOLLARS

SINCE FILE

TOTAL

ENTRY

SESSION

FULL ESTIMATED COST

0.22

0.22

FILE 'REGISTRY' ENTERED AT 15:10:28 ON 06 MAR 2009

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Property values tagged with IC are from the ZIC/VINITI data file provided by InfoChem.

STRUCTURE FILE UPDATES: 4 MAR 2009 HIGHEST RN 1115640-24-8

DICTIONARY FILE UPDATES: 4 MAR 2009 HIGHEST RN 1115640-24-8

New CAS Information Use Policies, enter HELP USAGETERMS for details.

TSCA INFORMATION NOW CURRENT THROUGH January 9, 2009.

Please note that search-term pricing does apply when conducting SmartSELECT searches.

REGISTRY includes numerically searchable data for experimental and predicted properties as well as tags indicating availability of experimental property data in the original document. For information on property searching in REGISTRY, refer to:

<http://www.cas.org/support/stngen/stdoc/properties.html>

=> s 6674-22-2/cn

L1 0 6674-22-2/CN

=> s 6674-22-2/rn

L2 1 6674-22-2/RN

=> file caplus

COST IN U.S. DOLLARS

SINCE FILE

TOTAL

ENTRY

SESSION

FULL ESTIMATED COST

7.75

7.97

FILE 'CAPLUS' ENTERED AT 15:13:10 ON 06 MAR 2009

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FILE COVERS 1907 - 6 Mar 2009 VOL 150 ISS 11

FILE LAST UPDATED: 5 Mar 2009 (20090305/ED)

Caplus now includes complete International Patent Classification (IPC) reclassification data for the third quarter of 2008.

CAS Information Use Policies apply and are available at:

<http://www.cas.org/legal/infopolicy.html>

This file contains CAS Registry Numbers for easy and accurate substance identification.

=> s L2

L3 3786 L2

=> file registry

COST IN U.S. DOLLARS

SINCE FILE

TOTAL

ENTRY

SESSION

FULL ESTIMATED COST

0.50

8.47

FILE 'REGISTRY' ENTERED AT 15:13:28 ON 06 MAR 2009

USE IS SUBJECT TO THE TERMS OF YOUR STN CUSTOMER AGREEMENT.

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Property values tagged with IC are from the ZIC/VINITI data file provided by InfoChem.

STRUCTURE FILE UPDATES: 4 MAR 2009 HIGHEST RN 1115640-24-8

DICTIONARY FILE UPDATES: 4 MAR 2009 HIGHEST RN 1115640-24-8

New CAS Information Use Policies, enter HELP USAGETERMS for details.

TSCA INFORMATION NOW CURRENT THROUGH January 9, 2009.

Please note that search-term pricing does apply when conducting SmartSELECT searches.

REGISTRY includes numerically searchable data for experimental and predicted properties as well as tags indicating availability of experimental property data in the original document. For information on property searching in REGISTRY, refer to:

<http://www.cas.org/support/stngen/stdoc/properties.html>

=> s 7320-37-8/rn

L4 1 7320-37-8/RN

=> d L4

L4 ANSWER 1 OF 1 REGISTRY COPYRIGHT 2009 ACS on STN

RN ***7320-37-8*** REGISTRY

ED Entered STN: 16 Nov 1984

CN Oxirane, 2-tetradecyl- (CA INDEX NAME)

OTHER CA INDEX NAMES:

CN Hexadecane, 1,2-epoxy- (6CI, 7CI, 8CI)
 CN Oxirane, tetradecyl- (9CI)
 OTHER NAMES:
 CN 1,2-Epoxyhexadecane
 CN 1,2-Epoxyhexadecene
 CN 1,2-Hexadecene epoxide
 CN 1,2-Hexadecylene oxide
 CN 1-Hexadecene oxide
 CN Cyracure UVR 6216
 CN Hexadecylene oxide
 CN Tetradecyloxirane
 CN UVR 6216
 CN Vikolox 16
 DR 151284-10-5
 MF C16 H32 O
 CI COM
 LC STN Files: ANABSTR, BEILSTEIN*, BIOSIS, CA, CAPLUS, CASREACT,
 CHEMCATS,
 CHEMINFORMRX, CHEMLIST, CSCHEM, CSNB, HSDB*, IFICDB, IFIPAT,
 IFIUDB,
 PIRA, PROMT, RTECS*, SPECINFO, TOXCENTER, USPAT2, USPATFULL,
 USPATOLD
 (*File contains numerically searchable property data)
 Other Sources: EINECS**, NDSL**, TSCA**
 (**Enter CHEMLIST File for up-to-date regulatory information)

/ Structure 1 in file .gra /

PROPERTY DATA AVAILABLE IN THE 'PROP' FORMAT

331 REFERENCES IN FILE CA (1907 TO DATE)
 103 REFERENCES TO NON-SPECIFIC DERIVATIVES IN FILE CA
 331 REFERENCES IN FILE CAPLUS (1907 TO DATE)

=> s 3001-72-7/rn
 L5 1 3001-72-7/RN

=> d L5

L5 ANSWER 1 OF 1 REGISTRY COPYRIGHT 2009 ACS on STN
 RN ***3001-72-7*** REGISTRY
 ED Entered STN: 16 Nov 1984
 CN Pyrrolo[1,2-a]pyrimidine, 2,3,4,6,7,8-hexahydro- (CA INDEX NAME)
 OTHER NAMES:
 CN 1,5-Diazabicyclo[4.3.0]non-5-ene
 CN 1,5-Diazobicyclo[4.3.0]non-5-ene
 CN 2,3,4,6,7,8-Hexahydropyrrolo[1,2-a]pyrimidine
 CN DBN
 CN DBN (heterocycle)
 CN NBU
 CN NSC 118106
 DR 25986-32-7, 312727-86-9
 MF C7 H12 N2
 CI COM
 LC STN Files: ANABSTR, BEILSTEIN*, BIOSIS, CA, CAPLUS, CASREACT,

CHEMCATS,
CHEMINFORMRX, CHEMLIST, CSCHEM, GMELIN*, IFICDB, IFIPAT, IFIUDB,
MEDLINE, MSDS-OHS, SPECINFO, SYNTHLINE, TOXCENTER, USPAT2,
USPATFULL,
USPATOLD
(*File contains numerically searchable property data)
Other Sources: EINECS**
(**Enter CHEMLIST File for up-to-date regulatory information)

/ Structure 2 in file .gra /

PROPERTY DATA AVAILABLE IN THE 'PROP' FORMAT

1055 REFERENCES IN FILE CA (1907 TO DATE)
40 REFERENCES TO NON-SPECIFIC DERIVATIVES IN FILE CA
1056 REFERENCES IN FILE CAPLUS (1907 TO DATE)

=> d L2

L2 ANSWER 1 OF 1 REGISTRY COPYRIGHT 2009 ACS on STN
RN ***6674-22-2*** REGISTRY
ED Entered STN: 16 Nov 1984
CN Pyrimido[1,2-a]azepine, 2,3,4,6,7,8,9,10-octahydro- (CA INDEX
NAME)
OTHER NAMES:
CN 1,8-Diaza-7-bicyclo[5.4.0]undecene
CN 1,8-Diazabicyclo[5.4.0]undec-7-ene
CN 1,8-Diazabicyclo[5.4.0]undecene-7
CN 2,3,4,6,7,8,9,10-Octahydropyrimido[1,2-a]azepine
CN Amicure DBUE
CN Dabco DBU
CN DBU
CN NSC 111184
CN NSC 230466
CN Polycat DBU
CN U-CAT SA 851
DR 51301-56-5, 69722-76-5, 78995-63-8, 83329-50-4, 31171-04-7, 41015-
70-7
MF C9 H16 N2
CI COM
LC STN Files: ANABSTR, BEILSTEIN*, BIOSIS, CA, CAPLUS, CASREACT,
CHEMCATS,
CHEMINFORMRX, CHEMLIST, CIN, CSCHEM, GMELIN*, IFICDB, IFIPAT,
IFIUDB,
MEDLINE, MSDS-OHS, SPECINFO, TOXCENTER, USPAT2, USPATFULL,
USPATOLD
(*File contains numerically searchable property data)
Other Sources: DSL**, EINECS**, TSCA**
(**Enter CHEMLIST File for up-to-date regulatory information)

/ Structure 3 in file .gra /

PROPERTY DATA AVAILABLE IN THE 'PROP' FORMAT

3773 REFERENCES IN FILE CA (1907 TO DATE)

147 REFERENCES TO NON-SPECIFIC DERIVATIVES IN FILE CA
3786 REFERENCES IN FILE CAPLUS (1907 TO DATE)

=> d his

(FILE 'HOME' ENTERED AT 15:10:14 ON 06 MAR 2009)

FILE 'REGISTRY' ENTERED AT 15:10:28 ON 06 MAR 2009

L1 0 S 6674-22-2/CN

L2 1 S 6674-22-2/RN

FILE 'CAPLUS' ENTERED AT 15:13:10 ON 06 MAR 2009

L3 3786 S L2

FILE 'REGISTRY' ENTERED AT 15:13:28 ON 06 MAR 2009

L4 1 S 7320-37-8/RN

L5 1 S 3001-72-7/RN

=> s triethylene (w) diamine

3806 TRIETHYLENE

438598 DIAMINE

76 DIAMINES

438598 DIAMINE

(DIAMINE OR DIAMINES)

L6 98 TRIETHYLENE (W) DIAMINE

=> s 280-57-9/rn

L7 1 280-57-9/RN

=> d L7

L7 ANSWER 1 OF 1 REGISTRY COPYRIGHT 2009 ACS on STN

RN ***280-57-9*** REGISTRY

ED Entered STN: 16 Nov 1984

CN 1,4-Diazabicyclo[2.2.2]octane (CA INDEX NAME)

OTHER NAMES:

CN 1,4-Ethylenepiperazine

CN 33LV

CN A 33

CN Activator 105E

CN Bicyclo[2.2.2]-1,4-diazaoctane

CN D 33LV

CN Dabco

CN Dabco 33LV

CN Dabco 3LV

CN DABCO Crystal

CN Dabco Crystalline

CN Dabco L 1202

CN Dabco S 25

CN Jeffcat TD 100

CN Kaolizer 31

CN L 33

CN L 33E

CN LC 96003

CN LV 33

CN Minico L 1020

CN N,N'-endo-Ethylenepiperazine

CN Niaux A 33

CN NSC 56362

CN PC CAT TD 33
 CN PC-TD
 CN Polycat 33LV
 CN TD 100
 CN TED
 CN TEDA
 CN Teda L 33
 CN Tegamine 33
 CN Tego Amine
 CN Texacat TD 100
 CN Texacat TD 33
 CN Thancat TD 33
 CN Thancat TD 33A
 CN Toral SM 2
 CN Toyocat L 33
 CN Toyocat TEDA L 33
 CN Triethylenediamine
 DR 903524-95-8, 165724-47-0, 23790-33-2, 101484-19-9, 150605-01-9,
 88935-43-7, 203072-11-1, 309955-09-7
 MF C6 H12 N2
 CI COM, RPS
 LC STN Files: AGRICOLA, ANABSTR, AQUIRE, BEILSTEIN*, BIOSIS,
 BIOTECHNO, CA,
 CAPLUS, CASREACT, CBNB, CHEMCATS, CHEMINFORMRX, CHEMLIST, CIN,
 CSCHEM,
 CSNB, DETHERM*, EMBASE, ENCOMPLIT, ENCOMPLIT2, ENCOMPPAT,
 ENCOMPPAT2,
 GMELIN*, HSDB*, IFICDB, IFIPAT, IFIUDB, MEDLINE, MRCK*, MSDS-OHS,
 PIRA,
 PROMT, RTECS*, SPECINFO, SYNTHLINE, TOXCENTER, ULIDAT, USPAT2,
 USPATFULL, USPATOLD
 (*File contains numerically searchable property data)
 Other Sources: DSL**, EINECS**, TSCA**
 (**Enter CHEMLIST File for up-to-date regulatory information)

/ Structure 4 in file .gra /

PROPERTY DATA AVAILABLE IN THE 'PROP' FORMAT

6376 REFERENCES IN FILE CA (1907 TO DATE)
 301 REFERENCES TO NON-SPECIFIC DERIVATIVES IN FILE CA
 6392 REFERENCES IN FILE CAPLUS (1907 TO DATE)

=> d his

(FILE 'HOME' ENTERED AT 15:10:14 ON 06 MAR 2009)

FILE 'REGISTRY' ENTERED AT 15:10:28 ON 06 MAR 2009

L1 0 S 6674-22-2/CN
 L2 1 S 6674-22-2/RN

FILE 'CAPLUS' ENTERED AT 15:13:10 ON 06 MAR 2009

L3 3786 S L2

FILE 'REGISTRY' ENTERED AT 15:13:28 ON 06 MAR 2009

L4 1 S 7320-37-8/RN
 L5 1 S 3001-72-7/RN

L6 98 S TRIETHYLENE (W) DIAMINE
L7 1 S 280-57-9/RN

=> file caplus uspatfull
COST IN U.S. DOLLARS

SINCE FILE	TOTAL
ENTRY	SESSION
21.78	30.25

FULL ESTIMATED COST
FILE 'CAPLUS' ENTERED AT 15:16:58 ON 06 MAR 2009
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FILE 'USPATFULL' ENTERED AT 15:16:58 ON 06 MAR 2009
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=> s (L2 OR L5 OR L7) AND L4
L8 4 (L2 OR L5 OR L7) AND L4

=> d L8 1-4 ti ibib

L8 ANSWER 1 OF 4 CAPLUS COPYRIGHT 2009 ACS on STN
TI Hydrocarbon desulfurization with mercaptan removal by treatment
with

alicyclic tertiary amines and nucleophilic acceptors
ACCESSION NUMBER: 2005:1027004 CAPLUS <<LOGINID::20090306>>
DOCUMENT NUMBER: 143:328922
TITLE: Hydrocarbon desulfurization with mercaptan
removal by

treatment with alicyclic tertiary amines and
nucleophilic acceptors
INVENTOR(S): Schield, John A.; Cappel, Weldon John
PATENT ASSIGNEE(S): Baker Hughes Incorporated, USA
SOURCE: PCT Int. Appl., 23 pp.
CODEN: PIXXD2

DOCUMENT TYPE: Patent
LANGUAGE: English
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
-----	---	----	-----	----
WO 2005087899	A1	20050922	WO 2004-US4011	
20040211				
W:	AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW			
RW:	BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM, AT, BE, BG, CH, CY, CZ, DE, DK,			

EE,
 ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI,
 SK,
 TR, BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN,
 TD, TG
 CA 2554548 A1 20050922 CA 2004-2554548
 20040211
 EP 1713885 A1 20061025 EP 2004-710238
 20040211
 R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC,
 PT,
 IE, SI, FI, RO, CY, TR, BG, CZ, EE, HU, SK
 US 20070142244 A1 20070621 US 2006-588341
 20060803
 PRIORITY APPLN. INFO.: WO 2004-US4011 W
 20040211
 OTHER SOURCE(S): MARPAT 143:328922
 REFERENCE COUNT: 5 THERE ARE 5 CITED REFERENCES AVAILABLE
 FOR THIS
 RECORD. ALL CITATIONS AVAILABLE IN THE RE

FORMAT

L8 ANSWER 2 OF 4 CAPLUS COPYRIGHT 2009 ACS on STN
 TI Study of the structure-reactivity relationships in the
 photoinitiated
 cationic polymerization of epoxide monomers
 ACCESSION NUMBER: 1998:808928 CAPLUS <<LOGINID::20090306>>
 DOCUMENT NUMBER: 130:182793
 TITLE: Study of the structure-reactivity relationships
 in the
 photoinitiated cationic polymerization of
 epoxide
 monomers
 AUTHOR(S): Crivello, James V.; Linzer, Volker
 CORPORATE SOURCE: Polymer Synthesis Center, Department of
 Chemistry,
 Rensselaer Polytechnic Institute, Troy, NY,
 12180-3590, USA
 SOURCE: Polimery (Warsaw) (1998), 43(11/12), 661-672
 CODEN: POLIA4; ISSN: 0032-2725
 PUBLISHER: Instytut Chemii Przemyslowej
 DOCUMENT TYPE: Journal
 LANGUAGE: English
 REFERENCE COUNT: 21 THERE ARE 21 CITED REFERENCES AVAILABLE
 FOR THIS
 RECORD. ALL CITATIONS AVAILABLE IN THE RE

FORMAT

L8 ANSWER 3 OF 4 CAPLUS COPYRIGHT 2009 ACS on STN
 TI Grease-compatible, hydrolytically stable encapsulant compositions
 for use
 in signal transmission devices
 ACCESSION NUMBER: 1991:103808 CAPLUS <<LOGINID::20090306>>
 DOCUMENT NUMBER: 114:103808
 ORIGINAL REFERENCE NO.: 114:17695a,17698a
 TITLE: Grease-compatible, hydrolytically stable
 encapsulant
 compositions for use in signal transmission
 devices
 INVENTOR(S): Croft, Thomas S.; Haugen, Hartwick A.

PATENT ASSIGNEE(S): Minnesota Mining and Manufacturing Co., USA
 SOURCE: Eur. Pat. Appl., 26 pp.
 CODEN: EPXXDW
 DOCUMENT TYPE: Patent
 LANGUAGE: English
 FAMILY ACC. NUM. COUNT: 1
 PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
EP 372747	A2	19900613	EP 1989-312078	
19891121				
EP 372747	A3	19901010		
EP 372747	B1	19950823		
R: AT, CH, DE, ES, FR, GB, IT, LI, SE				
AU 8945338	A	19900531	AU 1989-45338	
19891120				
AU 620662	B2	19920220		
ES 2076218	T3	19951101	ES 1989-312078	
19891121				
CA 2003781	A1	19900525	CA 1989-2003781	
19891124				
CA 2003781	C	19990216		
JP 02212580	A	19900823	JP 1989-306376	
19891124				
JP 2772075	B2	19980702		
KR 135973	B1	19980424	KR 1989-17080	
19891124				
BR 8905961	A	19900619	BR 1989-5961	
19891127				
PRIORITY APPLN. INFO.:			US 1988-274337	A
19881125				

L8 ANSWER 4 OF 4 USPATFULL on STN
 TI Encapsulant compositions for use in signal transmission devices
 ACCESSION NUMBER: 91:5171 USPATFULL <<LOGINID::20090306>>
 TITLE: Encapsulant compositions for use in signal transmission devices

INVENTOR(S): Croft, Thomas S., Austin, TX, United States
 Haugen, Hartwick, Austin, TX, United States
 PATENT ASSIGNEE(S): Minnesota Mining and Manufacturing, St. Paul, MN,
 United States (U.S. corporation)

NUMBER	KIND	DATE
PATENT INFORMATION:	US 4985475	19910115
APPLICATION INFO.:	US 1988-274337	19881125 (7)
RELATED APPLN. INFO.:	Continuation-in-part of Ser. No. US 1987-19295,	
filed	on 9 Mar 1987, now patented, Pat. No. US 4857563	
DOCUMENT TYPE:	Utility	
FILE SEGMENT:	Granted	
PRIMARY EXAMINER:	Schofer, Joseph L.	
ASSISTANT EXAMINER:	Mulcahy, Peter D.	
LEGAL REPRESENTATIVE:	Sell, D. M., Lilly, J. V.	
NUMBER OF CLAIMS:	17	
EXEMPLARY CLAIM:	1	

LINE COUNT: 1302
CAS INDEXING IS AVAILABLE FOR THIS PATENT.

=> d 1-4 hit, bib

L8 ANSWER 1 OF 4 CAPLUS COPYRIGHT 2009 ACS on STN
IT ***280-57-9*** , 1,4-Diazabicyclo[2.2.2]octane ***3001-72-7***
,
1,5-Diazabicyclo[4.3.0]non-5-ene ***6674-22-2*** ,
1,8-Diazabicyclo[5.4.0]undec-7-ene
RL: CFS (Chemical process); PEP (Physical, engineering or chemical
process); PROC (Process)
(hydrocarbon desulfurization with mercaptan removal by treatment
with
alicyclic tertiary amines and nucleophilic acceptors)
IT 463-73-0D, Chloroformic acid, compds. 2817-45-0D, Phosphoramidic
acid,
compds. ***7320-37-8*** , 1,2-Epoxyhexadecane 19270-07-6D,
Cyanofornic acid, compds.
RL: CFS (Chemical process); PEP (Physical, engineering or chemical
process); PROC (Process)
(nucleophilic acceptors; hydrocarbon desulfurization with
mercaptan
removal by treatment with alicyclic tertiary amines and
nucleophilic
acceptors)
AN 2005:1027004 CAPLUS <<LOGINID::20090306>>
DN 143:328922
TI Hydrocarbon desulfurization with mercaptan removal by treatment
with
alicyclic tertiary amines and nucleophilic acceptors
IN Schield, John A.; Cappel, Weldon John
PA Baker Hughes Incorporated, USA
SO PCT Int. Appl., 23 pp.
CODEN: PIXXD2
DT Patent
LA English
FAN.CNT 1

	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
	-----	----	-----	-----	-----
PI	WO 2005087899	A1	20050922	WO 2004-US4011	
20040211					
W:	AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA,				
CH,	CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB,				
GD,	GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ,				
LC,	LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA,				
NI,	NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL,				
SY,	TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM,				
ZW					
RW:	BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW, AM,				
AZ,	BY, KG, KZ, MD, RU, TJ, TM, AT, BE, BG, CH, CY, CZ, DE, DK,				
EE,					

ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI,
SK, TR, BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN,
TD, TG
CA 2554548 A1 20050922 CA 2004-2554548
20040211
EP 1713885 A1 20061025 EP 2004-710238
20040211
R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC,
PT, IE, SI, FI, RO, CY, TR, BG, CZ, EE, HU, SK
US 20070142244 A1 20070621 US 2006-588341
20060803
PRAI WO 2004-US4011 W 20040211
OS MARPAT 143:328922
RE.CNT 5 THERE ARE 5 CITED REFERENCES AVAILABLE FOR THIS RECORD
ALL CITATIONS AVAILABLE IN THE RE FORMAT

L8 ANSWER 2 OF 4 CAPLUS COPYRIGHT 2009 ACS on STN
IT 108-87-2, 1-Methylcyclohexane 291-64-5, Cycloheptane ***6674-
22-2***
, 1,8-Diazabicyclo[5.4.0]undec-7-ene 10353-53-4, 1,2-Epoxyhex-5-
ene
55334-42-4, 1,2-Dibromododecane 85721-25-1
RL: RCT (Reactant); RACT (Reactant or reagent)
(reactant in monomer prepn.; structure effect on kinetics of
photoinitiated cationic polymn. of epoxides)
IT 285-67-6, Epoxycyclopentane 286-20-4, 7-Oxabicyclo[4.1.0]heptane
286-62-4, Epoxycyclooctane 1436-34-6 1464-53-5, 2,2'-Bioxirane
1502-29-0, cis-Epoxycyclododecane 1686-14-2, .alpha.-Pinene oxide
1758-33-4, cis-2,3-Epoxybutane 2404-44-6 2426-07-5 2855-19-8
2984-50-1 3234-28-4 4683-60-7, trans-Epoxycyclododecane
7320-37-8 21490-63-1, trans-2,3-Epoxybutane
RL: PRP (Properties); RCT (Reactant); RACT (Reactant or reagent)
(structure effect on kinetics of photoinitiated cationic polymn.
of
epoxides)
AN 1998:808928 CAPLUS <<LOGINID::20090306>>
DN 130:182793
TI Study of the structure-reactivity relationships in the
photoinitiated
cationic polymerization of epoxide monomers
AU Crivello, James V.; Linzer, Volker
CS Polymer Synthesis Center, Department of Chemistry, Rensselaer
Polytechnic
Institute, Troy, NY, 12180-3590, USA
SO Polimery (Warsaw) (1998), 43(11/12), 661-672
CODEN: POLIA4; ISSN: 0032-2725
PB Instytut Chemii Przemyslowej
DT Journal
LA English
RE.CNT 21 THERE ARE 21 CITED REFERENCES AVAILABLE FOR THIS RECORD
ALL CITATIONS AVAILABLE IN THE RE FORMAT

L8 ANSWER 3 OF 4 CAPLUS COPYRIGHT 2009 ACS on STN
IT 101-34-8, Flexricin P 8 112-75-4 1191-43-1, 1,6-Hexanedithiol
3319-31-1 3489-28-9, 1,9-Nonanedithiol ***6674-22-2***
7320-37-8 , Vikolox 16 9044-17-1, Indopol H 100 10482-
56-1
25085-98-7, ERL 4221 25155-23-1, Trixylenyl phosphate 25231-21-

25266-02-8, PA-18 26616-47-7, ERL 4234 37226-48-5, Araldite
 53564-35-5, Escopol R020 81647-91-8, Paol 40 132325-11-2,
 FuelSaver
 RL: USES (Uses)
 (encapsulation compns. contg., grease-compatible, hydrolytically
 stable, for signal transmission devices)
 AN 1991:103808 CAPLUS <<LOGINID:20090306>>
 DN 114:103808
 OREF 114:17695a,17698a
 TI Grease-compatible, hydrolytically stable encapsulant compositions
 for use
 in signal transmission devices
 IN Croft, Thomas S.; Haugen, Hartwick A.
 PA Minnesota Mining and Manufacturing Co., USA
 SO Eur. Pat. Appl., 26 pp.
 CODEN: EPXXDW
 DT Patent
 LA English
 FAN.CNT 1

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
PI EP 372747	A2	19900613	EP 1989-312078	
19891121				
EP 372747	A3	19901010		
EP 372747	B1	19950823		
R: AT, CH, DE, ES, FR, GB, IT, LI, SE				
AU 8945338	A	19900531	AU 1989-45338	
19891120				
AU 620662	B2	19920220		
ES 2076218	T3	19951101	ES 1989-312078	
19891121				
CA 2003781	A1	19900525	CA 1989-2003781	
19891124				
CA 2003781	C	19990216		
JP 02212580	A	19900823	JP 1989-306376	
19891124				
JP 2772075	B2	19980702		
KR 135973	B1	19980424	KR 1989-17080	
19891124				
BR 8905961	A	19900619	BR 1989-5961	
19891127				
PRAI US 1988-274337	A	19881125		
L8 ANSWER 4 OF 4 USPATFULL on STN				
IT 101-34-8, Flexricin P 8 112-75-4 1191-43-1, 1,6-Hexanedithiol				
3319-31-1 3489-28-9, 1,9-Nonanedithiol ***6674-22-2***				
7320-37-8 , Vikolox 16 9044-17-1, Indopol H 100				
10482-56-1				
25085-98-7, ERL 4221 25155-23-1, Trixylenyl phosphate 25231-				
21-4				
25266-02-8, PA-18 26616-47-7, ERL 4234 37226-48-5, Araldite				
53564-35-5, Escopol R020 81647-91-8, Paol 40 132325-11-2,				
FuelSaver				
(encapsulation compns. contg., grease-compatible, hydrolytically				
stable, for signal transmission devices)				
AN 91:5171 USPATFULL <<LOGINID:20090306>>				
TI Encapsulant compositions for use in signal transmission devices				
IN Croft, Thomas S., Austin, TX, United States				

Haugen, Hartwick, Austin, TX, United States
 PA Minnesota Mining and Manufacturing, St. Paul, MN, United States
 (U.S. corporation)
 PI US 4985475 19910115
 AI US 1988-274337 19881125 (7)
 RLI Continuation-in-part of Ser. No. US 1987-19295, filed on 9 Mar
 1987, now patented, Pat. No. US 4857563
 DT Utility
 FS Granted
 EXNAM Primary Examiner: Schofer, Joseph L.; Assistant Examiner:
 Mulcahy, Peter
 D.
 LREP Sell, D. M., Lilly, J. V.
 CLMN Number of Claims: 17
 ECL Exemplary Claim: 1
 DRWN No Drawings
 LN.CNT 1302
 CAS INDEXING IS AVAILABLE FOR THIS PATENT.

=> s (L2 OR L5 OR L7) AND thiolysis
 L9 3 (L2 OR L5 OR L7) AND THIOLYSIS

=> d L9 1-3 hit, ibib

L9 ANSWER 1 OF 3 CAPLUS COPYRIGHT 2009 ACS on STN
 ST siloxane tetrahydro hydrogen rich prepn alcoholysis dihalosilane
 pyridine
 complex; alkylthio disilathiane tetrahydro hydrogen rich prepn
 thiolysis dihalosilane complex; process prepn hydrogen
 rich
 siloxane disilathiane alcoholysis ***thiolysis*** dihalosilane
 IT Amines, preparation
 RL: RCT (Reactant); SPN (Synthetic preparation); PREP
 (Preparation); RACT
 (Reactant or reagent)
 (complexes, silicon; process for prepn. of hydrogen-rich
 1,1,3,3-tetrahydrodisiloxanes and -disilathianes by alcoholysis
 and
 thiolysis of dihalosilane pyridine complexes)
 IT Siloxanes (nonpolymeric)
 RL: SPN (Synthetic preparation); PREP (Preparation)
 (disiloxanes, hydrogen-rich; process for prepn. of hydrogen-rich
 1,1,3,3-tetrahydrodisiloxanes and -disilathianes by alcoholysis
 and
 thiolysis of dihalosilane pyridine complexes)
 IT Alcoholysis
 (process for prepn. of hydrogen-rich 1,1,3,3-
 tetrahydrodisiloxanes and
 -disilathianes by alcoholysis and ***thiolysis*** of
 dihalosilane
 pyridine complexes)
 IT Group IVA element compounds
 Group VIA element compounds
 RL: SPN (Synthetic preparation); PREP (Preparation)
 (silathianes, 1,3-disilathianes; process for prepn. of hydrogen-
 rich
 1,1,3,3-tetrahydrodisiloxanes and -disilathianes by alcoholysis

and
 IT ***thiolysis*** of dihalosilane pyridine complexes)
 Alcohols, reactions
 Thiols, reactions
 RL: RCT (Reactant); RACT (Reactant or reagent)
 (tertiary; process for prepn. of hydrogen-rich
 1,1,3,3-tetrahydrodisiloxanes and -disilathianes by alcoholysis

and
 IT ***thiolysis*** of dihalosilane pyridine complexes)
 Solvolysis
 (***thiolysis*** ; process for prepn. of hydrogen-rich
 1,1,3,3-tetrahydrodisiloxanes and -disilathianes by alcoholysis

and
 IT ***thiolysis*** of dihalosilane pyridine complexes)
 953776-96-0P
 RL: PRPH (Prophetic); RCT (Reactant); SPN (Synthetic preparation);
 PREP
 (Preparation); RACT (Reactant or reagent)
 (process for prepn. of hydrogen-rich 1,1,3,3-
 tetrahydrodisiloxanes and
 -disilathianes by alcoholysis and ***thiolysis*** of
 dihalosilane
 pyridine complexes)

IT 75-65-0, tert-Butanol, reactions 75-66-1, tert-Butylmercaptan
 75-85-4,
 tert-Amyl alcohol 77-74-7 100-43-6, 4-Vinylpyridine 108-47-4,
 2,4-Dimethylpyridine 108-89-4, 4-Methylpyridine 108-99-6,
 3-Methylpyridine 109-06-8, 2-Methylpyridine 110-86-1, Pyridine,
 reactions 536-75-4, 4-Ethylpyridine 590-36-3 590-67-0 594-

83-2
 595-41-5 597-05-7 597-49-9 597-93-3 598-01-6 626-55-1,
 3-Bromopyridine 690-37-9 702-81-8, 3-Methyl-1-adamantanol
 768-95-6,
 Tricyclo[3.3.1.1³,7]decan-1-ol 880-49-9, 3-Isopropyl-1-
 adamantanol
 1122-58-3 1462-03-9, 1-Methylcyclopentanol 1569-44-4 1569-46-

6
 1604-02-0 1633-97-2 1639-01-6 1639-03-8 1679-09-0 1940-

18-7,
 1-Ethylcyclohexanol 3742-85-6 3761-94-2 3978-81-2,
 4-tert-Butylpyridine 4109-96-0, Dichlorosilane 5445-24-9

5827-80-5
 17257-32-8 20534-58-1, Bicyclo[2.2.2]octan-1-ol 23511-76-4
 71897-97-7 74356-31-3 87383-23-1 91337-12-1 108836-86-8
 116436-16-9 124547-52-0 186365-89-9 189394-12-5 200403-44-7
 RL: RCT (Reactant); RACT (Reactant or reagent)
 (process for prepn. of hydrogen-rich 1,1,3,3-
 tetrahydrodisiloxanes and
 -disilathianes by alcoholysis and ***thiolysis*** of
 dihalosilane
 pyridine complexes)

IT 75-50-3, Trimethylamine, reactions 79-55-0,
 1,2,2,6,6-Pentamethylpiperidine 100-76-5, 1-Azabicyclo[2.2.2]
 octane
 102-82-9, Tributylamine 121-44-8, Triethylamine, reactions
 280-57-9 , 1,4-Diazabicyclo[2.2.2]octane ***3001-72-7***

,
 1,5-Diazabicyclo[4.3.0]non-5-ene 4458-31-5 5807-14-7,
 1,5,7-Triazabicyclo[4.4.0]dec-5-ene ***6674-22-2*** ,
 1,8-Diazabicyclo[5.4.0]undec-7-ene 20634-92-8 84030-20-6,

7-Methyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene
 RL: RGT (Reagent); RACT (Reactant or reagent)
 (process for prepn. of hydrogen-rich 1,1,3,3-
 tetrahydrodisiloxanes and
 -disilathianes by alcoholysis and ***thiolysis*** of
 dihalosilane
 pyridine complexes)
 IT 1002788-53-5P 1002788-54-6P 1002788-55-7P
 RL: SPN (Synthetic preparation); PREP (Preparation)
 (process for prepn. of hydrogen-rich 1,1,3,3-
 tetrahydrodisiloxanes and
 -disilathianes by alcoholysis and ***thiolysis*** of
 dihalosilane
 pyridine complexes)
 ACCESSION NUMBER: 2008:90945 CAPLUS <<LOGINID::20090306>>
 DOCUMENT NUMBER: 148:168827
 TITLE: Process for preparation of novel hydrogen-rich
 1,1,3,3-tetrahydro-1,3-disiloxanes and
 1,3-disilathianes as precursors for
 hydrosilylation,
 polymerization and material modifiers
 Fester, Gerrit; Roewer, Gerhard; Kroke, Edwin
 PATENT ASSIGNEE(S): Technische Universitaet Bergakademie Freiberg,
 Germany
 SOURCE: PCT Int. Appl., 20pp.
 CODEN: PIXXD2
 DOCUMENT TYPE: Patent
 LANGUAGE: German
 FAMILY ACC. NUM. COUNT: 1
 PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
-----	----	-----	-----	-----
WO 2008009680	A1	20080124	WO 2007-EP57379	
20070717				
W:	AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,			
CA,	CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES,			
FI,	GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE,			
KG,	KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD,			
ME,	MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH,			
PL,	PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM,			
TN,	TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW			
IE,	RW: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU,			
BF,	IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR,			
BW,	BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG,			
AZ,	GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM,			
	BY, KG, KZ, MD, RU, TJ, TM			
PRIORITY APPLN. INFO.:			DE 2006-102006034336A	
20060717				

OTHER SOURCE(S): CASREACT 148:168827; MARPAT 148:168827
REFERENCE COUNT: 1 THERE ARE 1 CITED REFERENCES AVAILABLE
FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE
FORMAT

L9 ANSWER 2 OF 3 CAPLUS COPYRIGHT 2009 ACS on STN
TI Improved process for preparation of hydrosilanes containing alkoxy,
amino
and thiolate groups by alcoholysis, aminolysis and
thiolysis of
halosilanes in the presence of tertiary amine bases
ST silane hydrosilane alkoxy amino thiolate prepn process; alcoholysis
aminolysis ***thiolysis*** chlorosilane tertiary amine base
process
IT Silanes
RL: SPN (Synthetic preparation); TEM (Technical or engineered
material
use); PREP (Preparation); USES (Uses)
(alkoxy, hydrosilanes; process for prepn. of hydrosilanes contg.
alkoxy, amino and thioether substituents by alcoholysis,
aminolysis and
thiolysis of halosilanes in presence of tertiary amine
base)
IT Silanes
RL: RCT (Reactant); RACT (Reactant or reagent)
(halosilanes, hydrosilanes; process for prepn. of hydrosilanes
contg.
alkoxy, amino and thioether substituents by alcoholysis,
aminolysis and
thiolysis of halosilanes in presence of tertiary amine
base)
IT Thioethers
RL: SPN (Synthetic preparation); TEM (Technical or engineered
material
use); PREP (Preparation); USES (Uses)
(hydrosilane; process for prepn. of hydrosilanes contg. alkoxy,
amino
and thioether substituents by alcoholysis, aminolysis and
thiolysis of halosilanes in presence of tertiary amine
base)
IT Silanes
RL: RCT (Reactant); SPN (Synthetic preparation); TEM (Technical or
engineered material use); PREP (Preparation); RACT (Reactant or
reagent);
USES (Uses)
(hydrosilanes; process for prepn. of hydrosilanes contg. alkoxy,
amino
and thioether substituents by alcoholysis, aminolysis and
thiolysis of halosilanes in presence of tertiary amine
base)
IT Silazanes
RL: SPN (Synthetic preparation); TEM (Technical or engineered
material
use); PREP (Preparation); USES (Uses)
(hydrosilanes; process for prepn. of hydrosilanes contg. alkoxy,
amino
and thioether substituents by alcoholysis, aminolysis and
thiolysis of halosilanes in presence of tertiary amine
base)

IT 56-24-6 64-17-5, Ethanol, reactions 67-56-1, Methanol, reactions
67-63-0, Isopropanol, reactions 71-23-8, 1-Propanol, reactions
71-36-3, 1-Butanol, reactions 71-41-0, 1-Pentanol, reactions
75-08-1,
Ethanethiol 75-33-2, 2-Propanethiol 76-84-6, Triphenylmethanol
76-87-9 78-83-1, Isobutanol, reactions 96-41-3, Cyclopentanol
98-85-1 100-51-6, Benzenemethanol, reactions 103-49-1,
Dibenzylamine
107-03-9, 1-Propanethiol 107-18-6, Allyl alcohol, reactions
107-19-7,
2-Propyn-1-ol 108-18-9, Diisopropylamine 108-89-4, 4-
Methylpyridine
108-93-0, Cyclohexanol, reactions 108-95-2, Phenol, reactions
108-98-5, Benzenethiol, reactions 109-79-5, 1-Butanethiol 109-
89-7,
Diethylamine, reactions 110-89-4, Piperidine, reactions 110-96-
3,
Diisobutylamine 111-92-2, Dibutylamine 115-19-5 123-51-3
123-75-1,
Pyrrolidine, reactions 142-84-7, Dipropylamine 513-42-8 513-
44-0
583-59-5, 2-Methylcyclohexanol 597-52-4, Triethylsilanol 598-
32-3,
3-Buten-2-ol 627-27-0, 3-Buten-1-ol 764-01-2, 2-Butyn-1-ol
791-31-1
894-08-6 927-74-2, 3-Butyn-1-ol 994-32-1 1066-40-6,
Trimethylsilanol
1067-96-5 1067-97-6 1189-31-7 1529-27-7, Triphenylgermanol
1529-35-7 1569-69-3, Cyclohexanethiol 1679-07-8,
Cyclopentanethiol
2028-63-9, 3-Butyn-2-ol 2216-51-5, (-)-Menthol 2622-89-1,
Borinic
acid, diphenyl- 2628-46-8 3695-77-0 4109-96-0, Dichlorosilane
4237-48-3 4426-31-7 4453-82-1 4631-63-4 5337-72-4 5906-
79-6
6117-91-5, 2-Buten-1-ol 6300-99-8 13061-97-7 13121-70-5
15356-60-2, (+)-Menthol 17546-98-4, Trimethylplumbanol 17687-
73-9
17687-74-0 17877-23-5 17888-60-7 18388-85-7 18547-88-1,
Tricyclohexylsilanol 26819-05-6 36633-36-0 52102-16-6
55999-97-8
56889-90-8, Tri-tert-butylsilanol 66952-11-2 82490-11-7
96383-35-6
98156-23-1 104503-69-7 118978-84-0 134178-80-6 171503-79-0
228092-38-4 317374-14-4 718642-35-4 855637-46-6 860704-01-4
952755-22-5 952755-23-6 952755-24-7 952755-25-8 952755-26-9
952755-27-0 952755-28-1 952755-29-2 952755-30-5 952755-31-6
952755-32-7 952755-33-8 952755-34-9
RL: RCT (Reactant); RACT (Reactant or reagent)
(process for prepn. of hydrosilanes contg. alkoxy, amino and
thioether
substituents by alcoholysis, aminolysis and ***thiolysis***
of
halosilanes in presence of tertiary amine base)
IT 952755-20-3P 952755-21-4P 953776-96-0P
RL: RCT (Reactant); SPN (Synthetic preparation); PREP
(Preparation); RACT
(Reactant or reagent)
(process for prepn. of hydrosilanes contg. alkoxy, amino and

thioether
substituents by alcoholysis, aminolysis and ***thiolysis***
of
halosilanes in presence of tertiary amine base)
IT 75-50-3, Trimethylamine, reactions 110-86-1, Pyridine, reactions
121-44-8, Triethylamine, reactions ***280-57-9*** ,
1,4-Diazabicyclo[2.2.2]octane 289-95-2, Pyrimidine 290-37-9,
Pyrazine
3001-72-7 4458-31-5 ***6674-22-2*** , DBU 20634-
92-8
RL: RGT (Reagent); RACT (Reactant or reagent)
(process for prepn. of hydrosilanes contg. alkoxy, amino and
thioether
substituents by alcoholysis, aminolysis and ***thiolysis***
of
halosilanes in presence of tertiary amine base)
IT 1507-99-9P 2487-90-3P 5314-52-3P 6675-79-2P 18165-68-9P
18165-77-0P 20114-49-2P 27804-64-4P 38442-21-6P,
Diphenoxysilane
149578-93-8P 220214-19-7P 859765-44-9P 952755-06-5P 952755-
07-6P 952755-08-7P 952755-09-8P 952755-10-1P 952755-11-2P 952755-
12-3P 952755-13-4P 952755-14-5P 952755-15-6P 952755-16-7P 952755-
17-8P 952755-18-9P 952755-19-0P
RL: SPN (Synthetic preparation); TEM (Technical or engineered
material
use); PREP (Preparation); USES (Uses)
(process for prepn. of hydrosilanes contg. alkoxy, amino and
thioether
substituents by alcoholysis, aminolysis and ***thiolysis***
of
halosilanes in presence of tertiary amine base)
ACCESSION NUMBER: 2007:1204421 CAPLUS <<LOGINID::20090306>>
DOCUMENT NUMBER: 147:486546
TITLE: Improved process for preparation of
hydrosilanes
containing alkoxy, amino and thiolato groups by
alcoholysis, aminolysis and ***thiolysis***
of
halosilanes in the presence of tertiary amine
bases
INVENTOR(S): Fester, Gerrit; Roewer, Gerhard; Kroke, Edwin
PATENT ASSIGNEE(S): Technische Universitaet Bergakademie Freiberg,
Germany
SOURCE: PCT Int. Appl., 43pp.
CODEN: PIXXD2
DOCUMENT TYPE: Patent
LANGUAGE: German
FAMILY ACC. NUM. COUNT: 1
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
WO 2007118474	A2	20071025	WO 2007-DE724	
20070419				
WO 2007118474	A3	20071221		
W: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,				

CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,
 GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG,
 KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, MG,
 MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT,
 RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR,
 TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW
 RW: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU,
 IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR,
 BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG,
 BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM,
 AZ, BY, KG, KZ, MD, RU, TJ, TM, AP, EA, EP, OA
 DE 102006019016 A1 20071025 DE 2006-102006019016
 20060419
 PRIORITY APPLN. INFO.: DE 2006-102006019016A
 20060419 DE 2006-102006034335A
 20060717
 OTHER SOURCE(S): CASREACT 147:486546; MARPAT 147:486546

L9 ANSWER 3 OF 3 CAPLUS COPYRIGHT 2009 ACS on STN
 IT Solvolysis catalysts
 (***thiolysis*** ; compn. for depilation contg. complexes of
 aluminum or zinc complexes with thioglycolic acid)
 IT 102-71-6, Triethanolamine, biological studies ***280-57-9*** ,
 1,4-Diazabicyclo[2.2.2]octane ***6674-22-2*** ,
 1,8-Diazabicyclo[5.4.0]undec-7-ene
 RL: CAT (Catalyst use); COS (Cosmetic use); BIOL (Biological
 study); USES
 (Uses)
 (compn. for depilation contg. complexes of aluminum or zinc
 complexes
 with thioglycolic acid)
 ACCESSION NUMBER: 2006:1354152 CAPLUS <<LOGINID:20090306>>
 DOCUMENT NUMBER: 146:106772
 TITLE: Composition for depilation containing complexes
 of
 aluminum or zinc complexes with thioglycolic
 acid
 INVENTOR(S): Marte, Walter; Meyer, Martin; Dutler, Hans;
 Zimmermann, Michael
 PATENT ASSIGNEE(S): Tex-A-Tec AG, Switz.
 SOURCE: PCT Int. Appl., 47pp.
 CODEN: PIXXD2
 DOCUMENT TYPE: Patent
 LANGUAGE: German
 FAMILY ACC. NUM. COUNT: 2
 PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
-----	----	----	-----	-----

 WO 2006136441 A1 20061228 WO 2006-EP6080
 20060623
 W: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA,
 CH,
 CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB,
 GD,
 GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN,
 KP,
 KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK,
 MN,
 MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS,
 RU,
 SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA,
 UG,
 US, UZ, VC, VN, ZA, ZM, ZW
 RW: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU,
 IE,
 IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR, BF,
 BJ,
 CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG, BW,
 GH,
 GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM, AZ,
 BY,
 KG, KZ, MD, RU, TJ, TM
 EP 1736207 A1 20061227 EP 2005-13593
 20050623
 R: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU,
 IE,
 IS, IT, LI, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR, AL,
 BA,
 HR, LV, MK, YU
 EP 1779899 A1 20070502 EP 2005-26090
 20051130
 R: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU,
 IE,
 IS, IT, LI, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR,
 AL,
 BA, HR, MK, YU
 EP 1917073 A1 20080507 EP 2006-762166
 20060623
 R: AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU,
 IE,
 IS, IT, LI, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR
 PRIORITY APPLN. INFO.: EP 2005-13593 A
 20050623 EP 2005-26090 A
 20051130 WO 2006-EP6080 W
 20060623
 REFERENCE COUNT: 7 THERE ARE 7 CITED REFERENCES AVAILABLE
 FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE
 FORMAT

=> s (L2 OR L5 OR L7) AND epoxide
 L10 489 (L2 OR L5 OR L7) AND EPOXIDE

=> s L10 and (mercaptan OR thiol)

L11 85 L10 AND (MERCAPTAN OR THIOL)

=> d L11 1-85 ti

L11 ANSWER 1 OF 85 CAPLUS COPYRIGHT 2009 ACS on STN
TI Process for preparation of substituted 2-aminoethylsulfonic acids

L11 ANSWER 2 OF 85 CAPLUS COPYRIGHT 2009 ACS on STN
TI Tertiary amines as highly efficient catalysts in the ring-opening reactions of ***epoxides*** with amines or ***thiols*** in

H2O: expeditious approach to .beta.-amino alcohols and .beta.-aminothioethers

L11 ANSWER 3 OF 85 CAPLUS COPYRIGHT 2009 ACS on STN
TI Hydrocarbon desulfurization with ***mercaptan*** removal by treatment with alicyclic tertiary amines and nucleophilic acceptors

L11 ANSWER 4 OF 85 CAPLUS COPYRIGHT 2009 ACS on STN
TI Artificial neural network for predicting the toxicity of organic molecules

L11 ANSWER 5 OF 85 CAPLUS COPYRIGHT 2009 ACS on STN
TI Regio- and stereospecific synthesis of (O-TIPS)-protected 2-hydroxyalkylmercaptans from ***epoxides*** and triisopropylsilanethiol

L11 ANSWER 6 OF 85 CAPLUS COPYRIGHT 2009 ACS on STN
TI Reaction of 1,2-dioxetanes with heteroatom nucleophiles: adduct formation by nucleophilic attack at the peroxide bond

L11 ANSWER 7 OF 85 CAPLUS COPYRIGHT 2009 ACS on STN
TI Polymercaptan-fused ring amine catalysts for curing epoxy resins

L11 ANSWER 8 OF 85 USPATFULL on STN
TI ORGANOMETALLIC COMPOSITIONS AND COATING COMPOSITIONS

L11 ANSWER 9 OF 85 USPATFULL on STN
TI Thiourethane Compositions and Processes for Making and Using Same

L11 ANSWER 10 OF 85 USPATFULL on STN
TI SEQUENTIAL ANALYSIS OF BIOLOGICAL SAMPLES

L11 ANSWER 11 OF 85 USPATFULL on STN
TI SEQUENTIAL ANALYSIS OF BIOLOGICAL SAMPLES

L11 ANSWER 12 OF 85 USPATFULL on STN
TI Method of producing flexible laminates

L11 ANSWER 13 OF 85 USPATFULL on STN
TI Synthesis and Applications of 2-Oxo-4-Methylthiobutyric Acid, Its Salts and Its Derivatives

L11 ANSWER 14 OF 85 USPATFULL on STN
TI FLUORESCENT BIOMOLECULE LABELING REAGENTS

L11 ANSWER 15 OF 85 USPATFULL on STN

TI Process of Preparing Esters and Ethers of Probulcol and
Derivatives
Thereof

L11 ANSWER 16 OF 85 USPATFULL on STN

TI Hardener for Epoxy Resin and Epoxy Resin Composition

L11 ANSWER 17 OF 85 USPATFULL on STN

TI MICROBIAL TRANSFORMATION METHOD FOR THE PREPARATION OF AN
EPOTHILONE

L11 ANSWER 18 OF 85 USPATFULL on STN

TI ***MERCAPTAN*** -HARDENED EPOXY POLYMER COMPOSITIONS AND
PROCESSES
FOR MAKING AND USING SAME

L11 ANSWER 19 OF 85 USPATFULL on STN

TI POLYMER COMPOSITIONS AND PROCESSES FOR MAKING AND USING SAME

L11 ANSWER 20 OF 85 USPATFULL on STN

TI Copper-catalyzed formation of carbon-heteroatom and carbon-carbon
bonds

L11 ANSWER 21 OF 85 USPATFULL on STN

TI ORGANOMETALLIC COMPOSITIONS AND COATING COMPOSITIONS

L11 ANSWER 22 OF 85 USPATFULL on STN

TI Pyrrolotriazine inhibitors of kinases

L11 ANSWER 23 OF 85 USPATFULL on STN

TI Polythioethane compositions and processes for making and using
same

L11 ANSWER 24 OF 85 USPATFULL on STN

TI Retroviral protease inhibitors

L11 ANSWER 25 OF 85 USPATFULL on STN

TI Retroviral protease inhibitors

L11 ANSWER 26 OF 85 USPATFULL on STN

TI ***Thiol*** ester compositions and processes for making and
using
same

L11 ANSWER 27 OF 85 USPATFULL on STN

TI Organometallic compositions and coating compositions

L11 ANSWER 28 OF 85 USPATFULL on STN

TI Pyrrolotriazine inhibitors of kinases

L11 ANSWER 29 OF 85 USPATFULL on STN

TI Controlled release fertilizer material and process for production
thereof

L11 ANSWER 30 OF 85 USPATFULL on STN

TI Pyrrolotriazine inhibitors of kinases

L11 ANSWER 31 OF 85 USPATFULL on STN

TI Process of preparing esters and ethers of probucol and
derivatives

thereof

L11 ANSWER 32 OF 85 USPATFULL on STN

TI Radiation-curable coatings for plastic substrates for multifunctional acrylate oligomers

L11 ANSWER 33 OF 85 USPATFULL on STN

TI Copper-catalyzed formation of carbon heteroatom and carbon-carbon bonds

L11 ANSWER 34 OF 85 USPATFULL on STN

TI Anionic and Lewis base photopolymerization process and its use for making optical articles

L11 ANSWER 35 OF 85 USPATFULL on STN

TI ***Thiol*** ester compositions and processes for making and using same

L11 ANSWER 36 OF 85 USPATFULL on STN

TI ***Thiol*** ester compositions and processes for making and using same

L11 ANSWER 37 OF 85 USPATFULL on STN

TI Compositions useful as coatings, their preparation, and articles made therefrom

L11 ANSWER 38 OF 85 USPATFULL on STN

TI Anionic and Lewis base photopolymerization process and its use for making optical articles

L11 ANSWER 39 OF 85 USPATFULL on STN

TI Photocrosslinked hydrogel blend surface coatings

L11 ANSWER 40 OF 85 USPATFULL on STN

TI Dual cure reaction products of self-photoinitiating multifunctional acrylates with ***thiols*** and synthetic methods

L11 ANSWER 41 OF 85 USPATFULL on STN

TI Photoactivable nitrogen bases

L11 ANSWER 42 OF 85 USPATFULL on STN

TI Novel mono- and di-fluorinated bezothiepine compounds as inhibitors of apical sodium co-dependent bile acid transport (ASBT) and taurocholate uptake

L11 ANSWER 43 OF 85 USPATFULL on STN

TI Microbial transformation method for the preparation of an epothilone

L11 ANSWER 44 OF 85 USPATFULL on STN

TI Microbial transformation method for the preparation of an

epothilone

L11 ANSWER 45 OF 85 USPATFULL on STN

TI Derivatives of gambogic acid and analogs as activators of caspases and inducers of apoptosis

L11 ANSWER 46 OF 85 USPATFULL on STN

TI Method for anion-exchange adsorption and anion-exchangers

L11 ANSWER 47 OF 85 USPATFULL on STN

TI Novel mono- and di-fluorinated benzothiepine compounds as inhibitors of apical sodium co-dependent bile acid transport (ASBT) and taurocholate uptake

L11 ANSWER 48 OF 85 USPATFULL on STN

TI Dental polymer film

L11 ANSWER 49 OF 85 USPATFULL on STN

TI Copper-catalyzed formation of carbon-heteroatom and carbon-carbon bonds

L11 ANSWER 50 OF 85 USPATFULL on STN

TI Novel benzothiepinines having activity as inhibitors of ileal bile acid transport and taurocholate uptake

L11 ANSWER 51 OF 85 USPATFULL on STN

TI Lactacystin analogs

L11 ANSWER 52 OF 85 USPATFULL on STN

TI Process for the preparation of 3,7-disubstituted-2,3,4,5-tetrahydro-1H-1,4-benzodiazepine compounds

L11 ANSWER 53 OF 85 USPATFULL on STN

TI High strength epoxy adhesive and uses thereof

L11 ANSWER 54 OF 85 USPATFULL on STN

TI Copper-catalyzed formation of carbon-heteroatom and carbon-carbon bonds

L11 ANSWER 55 OF 85 USPATFULL on STN

TI Retroviral protease inhibitors

L11 ANSWER 56 OF 85 USPATFULL on STN

TI Composition of epoxy resin, chain extender and polymeric toughener with separate base catalyst

L11 ANSWER 57 OF 85 USPATFULL on STN

TI Inhibiting discoloration of halogen-containing polymers after radiation

L11 ANSWER 58 OF 85 USPATFULL on STN

TI Thiolamide curing agents

L11 ANSWER 59 OF 85 USPATFULL on STN

TI Substituted 5-aryl-benzothiepienes having activity as inhibitors of ileal bile acid transport and taurocholate uptake

L11 ANSWER 60 OF 85 USPATFULL on STN
 TI Primerless substrate repair with polyepoxide and polythiol

L11 ANSWER 61 OF 85 USPATFULL on STN
 TI Reacting methylene and alkene components in presence of tertiary amine reacted with ***epoxide***

L11 ANSWER 62 OF 85 USPATFULL on STN
 TI Isocyanate reactive blends and internal mould release composites

L11 ANSWER 63 OF 85 USPATFULL on STN
 TI Isocyanate reactive blends and internal mould release compositions

L11 ANSWER 64 OF 85 USPATFULL on STN
 TI Heat-curable reaction resin mixtures and the use thereof

L11 ANSWER 65 OF 85 USPATFULL on STN
 TI Thermally curable mixture containing epoxy and formamide compounds

L11 ANSWER 66 OF 85 USPATFULL on STN
 TI Isocyanate reactive blends and internal mould release compositions

L11 ANSWER 67 OF 85 USPATFULL on STN
 TI Decarboxylation processes using mixed metal oxide catalysts

L11 ANSWER 68 OF 85 USPATFULL on STN
 TI Reaction product of olefinically unsaturated compounds with compounds containing active hydrogen, processes for their preparation and 2-component lacquers based thereon

L11 ANSWER 69 OF 85 USPATFULL on STN
 TI Encapsulant compositions for use in signal transmission devices

L11 ANSWER 70 OF 85 USPATFULL on STN
 TI Polyamines and a process for the production thereof

L11 ANSWER 71 OF 85 USPATFULL on STN
 TI Reaction product of olefinically unsaturated compounds with compounds containing active hydrogen, processes for their preparation and 2-component lacquers based thereon HOE 85/F 036J

L11 ANSWER 72 OF 85 USPATFULL on STN
 TI Tin or bismuth complex catalysts and trigger cure of coatings therewith

L11 ANSWER 73 OF 85 USPATFULL on STN
 TI Rapid curing epoxy compositions

L11 ANSWER 74 OF 85 USPATFULL on STN
 TI Epoxy/nucleophile transesterification catalysts and thermoset

coatings

L11 ANSWER 75 OF 85 USPATFULL on STN
TI Powder coatings with catalyzed transesterification cure

L11 ANSWER 76 OF 85 USPATFULL on STN
TI Heat-hardenable ***epoxide*** resin mixtures

L11 ANSWER 77 OF 85 USPATFULL on STN
TI Modified disulfide polymer composition and method for making same
from ***mercaptan*** terminated disulfide polymer and diethyl
formal ***mercaptan*** terminated polysulfide

L11 ANSWER 78 OF 85 USPATFULL on STN
TI Transesterification process

L11 ANSWER 79 OF 85 USPATFULL on STN
TI Polyamines and a process for their production

L11 ANSWER 80 OF 85 USPATFULL on STN
TI Process for the preparation of polyamines from N-monoaryl-N',N'-
dialkyl urea compounds and their use for the synthesis of polyurethanes

L11 ANSWER 81 OF 85 USPATFULL on STN
TI N-[2-Amino(oxy- or thia- group-substituted-
cycloaliphatic)]benzeneacetamides and -benzamide analgesics

L11 ANSWER 82 OF 85 USPATFULL on STN
TI Process for the preparation of stabilized polymer dispersions in
polyol at low temperature

L11 ANSWER 83 OF 85 USPATFULL on STN
TI Broken-down organic lignin-cellulose silicate polymers

L11 ANSWER 84 OF 85 USPATFULL on STN
TI Polyepoxide curing by polymercaptans catalyzed by dimethylamino
alkyl ethers

L11 ANSWER 85 OF 85 USPATFULL on STN
TI High resilience flexible foamed polyurethanes, foamable mixtures
and process therefor

=> d 26,31,36 hit ibib

L11 ANSWER 26 OF 85 USPATFULL on STN
TI ***Thiol*** ester compositions and processes for making and
using same
AB ***Thiol*** ester compositions, methods of making the
thiol ester compositions, and methods of using the ***thiol***
ester compositions are provided. In some embodiments, the ***thiol***

ester compositions include ***thiol*** esters, hydroxy
 thiol
 esters and cross-linked ***thiol*** esters. The ***thiol***
 ester composition can be used to produce cross-linked
 thiol
 esters, sulfonic acid-containing esters, sulfonate containing
 esters and
 thioacrylate containing esters. The ***thiol*** ester
 compositions
 can be used to produce polythiourethanes. The polythiourethanes
 can be
 used in fertilizers and fertilizer coatings.
 SUMM The invention relates to ***thiol*** containing ester
 compositions
 generally made from a reaction of unsaturated ester compositions
 and a
 material capable of forming a ***thiol*** group. The
 invention also
 relates to the processes for preparing such ***thiol***
 containing
 compositions and uses for the ***thiol*** containing
 compositions.

SUMM The present invention advantageously provides ***thiol***
 containing compositions and methods of making such compositions.
 In
 addition to the compositions and methods of making such
 compositions,
 products that include such compositions are also provided.

SUMM As an embodiment of the present invention, a ***thiol***
 ester
 composition is advantageously provided. In this embodiment, the
 thiol ester composition includes ***thiol*** ester
 molecules
 that have an average of at least 1.5 ester groups per
 thiol
 ester molecule. The ***thiol*** ester molecules also have an
 average
 of at least 1.5 ***thiol*** groups per ***thiol*** ester
 molecule. The ***thiol*** ester molecules also have a molar
 ratio of
 cyclic sulfides to ***thiol*** groups of less than 1.5.

SUMM In some aspects, the ***thiol*** ester molecules have a
 molar ratio
 of cyclic sulfides to ***thiol*** groups ranging from 0 to
 1.0. In
 some aspects, the ***thiol*** ester molecules have an average
 ranging from 1.5 to 9 ***thiol*** groups per ***thiol***
 ester
 molecule. In some embodiments, the ***thiol*** ester
 molecules have
 a molar ratio of carbon-carbon double bonds to ***thiol***
 groups of
 less than 1.5.

SUMM The amount of ***thiol*** sulfur or ***mercaptan***
 sulfur
 contained within the ***thiol*** ester molecules can also

vary. For example, in some embodiments, the ***thiol*** ester molecules have an average of greater than 5 weight percent ***thiol*** sulfur. In other embodiments, the ***thiol*** ester molecules have an average ranging from 8 to 10 weight percent ***thiol*** sulfur. In some embodiments, the ***thiol*** ester molecules have an average of less than 30 mole percent sulfur, which is present as cyclic sulfides. Alternatively, the ***thiol*** ester molecules have an average of less than 2 mole percent sulfur present as cyclic sulfides.

SUMM In some embodiments, the ***thiol*** ester molecules are produced from unsaturated esters that have an average of less than 25 weight percent of side chains that include 3 contiguous methylene interrupted carbon-carbon double bonds. In another aspect, greater than 40 percent of the total side chains contained within the ***thiol*** ester molecules contain sulfur.

SUMM In addition to the ***thiol*** ester composition, a process for producing the ***thiol*** ester composition is advantageously provided as another embodiment of the present invention. To produce the ***thiol*** ester composition, hydrogen sulfide is contacted with an unsaturated ester composition. The unsaturated ester composition includes unsaturated esters that have an average of at least 1.5 ester groups per unsaturated ester molecule. The unsaturated esters also have an average of at least 1.5 carbon-carbon double bonds per unsaturated ester molecule. The hydrogen sulfide and the unsaturated esters are reacted to produce or form the ***thiol*** ester composition. The ***thiol*** ester composition advantageously includes ***thiol*** ester molecules that have a molar ratio of cyclic sulfides to ***thiol*** groups of less than 1.5.

SUMM Another process for producing the ***thiol*** ester composition is advantageously provided as another embodiment of the present invention. In this process embodiment, the hydrogen sulfide and the unsaturated ester composition are contacted. The unsaturated ester composition includes unsaturated esters having an average of at least 1.5

ester groups per unsaturated ester molecule and having an average of at least 1.5 carbon-carbon double bonds per unsaturated ester molecule. The hydrogen sulfide and the unsaturated esters are then reacted in a substantial absence of a solvent to form the ***thiol*** ester composition. The ***thiol*** ester composition includes ***thiol*** ester molecules. The ***thiol*** ester composition advantageously includes ***thiol*** ester molecules that have a molar ratio of cyclic sulfides to ***thiol*** groups of less than 1.5.

SUMM The resulting ***thiol*** ester molecules produced by this process possess advantageous characteristics. For example, in some embodiments, the ***thiol*** ester molecules have a molar ratio of the hydrogen sulfide to carbon-carbon double bonds of greater than 2. As another example, in other embodiments, the ***thiol*** ester molecules have an average of greater than 5 weight percent ***thiol*** sulfur. In some aspects, greater than 40 percent of the ***thiol*** ester molecule total side chains contain sulfur.

SUMM As another embodiment of the present invention, another process for preparing the ***thiol*** ester composition is advantageously provided. In this embodiment, a polyol composition and a ***thiol*** carboxylic acid composition are contacted and reacted to produce the ***thiol*** ester composition. The ***thiol*** ester composition includes ***thiol*** ester molecules having an average of at least 1.5 ester groups per ***thiol*** ester molecule and having an average of at least 1.5 ***thiol*** groups per ***thiol*** ester molecule.

SUMM In addition to the ***thiol*** ester composition, other compositions are advantageously provided as embodiments of the present invention. For example, a hydroxy ***thiol*** ester composition is provided as another embodiment of the present invention. The hydroxyl ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules having an average of at least 1.5 ester groups per hydroxy

1.5 ***thiol*** ester molecule and having an average of at least
ester .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol***
 molecule.

SUMM As described herein, the .alpha.-hydroxy ***thiol*** groups
contain an alcohol or hydroxy group and a ***thiol*** group within
the same group. In embodiments of the present invention, the .alpha.-
hydroxy ***thiol*** groups can be replaced with separate alcohol and
 thiol groups. In these embodiments, the same number of
.alpha.-hydroxy ***thiol*** groups can be used for the separate alcohol and
 thiol groups. For example, in some embodiments, the
hydroxy ***thiol*** ester molecules have an average of at least 1.5
 .alpha.-hydroxy ***thiol*** groups. In embodiments that
contain separate alcohol and ***thiol*** groups, the hydroxy
thiol
ester molecules would contain an average of at least 1.5 alcohol
groups
and an average of at least 1.5 ***thiol*** groups.

SUMM In some aspects, the hydroxy ***thiol*** ester molecules
have an average ranging from 1.5 to 9 .alpha.-hydroxy ***thiol***
groups per
hydroxy ***thiol*** ester molecule. In some embodiments, the
 thiol ester molecules have a molar ratio of carbon-
carbon double
bonds to ***thiol*** groups of less than 1.5.

SUMM In some embodiments, the ***thiol*** ester molecules are
produced
from unsaturated esters that have an average of less than 25
weight
percent of side chains that include 3 contiguous methylene
interrupted
carbon-carbon double bonds. In another aspect, greater than 40
percent
of the total side chains contained within the .alpha.-hydroxy
 thiol ester molecules contain sulfur.

SUMM The amount of ***thiol*** sulfur contained within the
hydroxy ***thiol*** ester molecules can also vary. For example, in
some
embodiments, the hydroxy ***thiol*** ester molecules have an
average
of greater than 5 weight percent ***thiol*** sulfur. In other
embodiments, the hydroxy ***thiol*** ester molecules have an
average
ranging from 8 to 10 weight percent ***thiol*** sulfur.

SUMM In some embodiments, the hydroxy ***thiol*** ester molecules
have a
molar ratio of ***epoxide*** groups to the .alpha.-hydroxy

thiol groups of less than 2. In other aspects, the composition is substantially free of ***epoxide*** groups.

SUMM In addition to the hydroxy ***thiol*** ester composition, methods or processes for making the hydroxy ***thiol*** ester composition are advantageously provided as embodiments of the present invention. In an embodiment, a process for preparing the hydroxy ***thiol*** ester composition is provided that includes the step of contacting the hydrogen sulfide and an epoxidized unsaturated ester composition. The epoxidized unsaturated ester composition includes epoxidized esters having an average of at least 1.5 ester groups per epoxidized unsaturated ester molecule and having an average of at least 1.5 ***epoxide*** groups per epoxidized unsaturated ester molecule. The hydrogen sulfide and the epoxidized unsaturated esters are then reacted to form the hydroxy ***thiol*** ester composition.

SUMM In some embodiments, a molar ratio of the hydrogen sulfide to ***epoxide*** groups in the epoxidized unsaturated esters is greater than 1.

SUMM Another process for preparing the hydroxy ***thiol*** ester composition is advantageously provided as another embodiment of the present invention. In this process embodiment, a polyol composition and a hydroxy ***thiol*** carboxylic acid composition are contacted and reacted to produce the hydroxy ***thiol*** ester composition. In this embodiment, the hydroxy ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules having an average of at least 1.5 ester groups per hydroxy ***thiol*** ester molecule and having an average of at least 1.5 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule.

SUMM A cross-linked ***thiol*** ester composition is advantageously provided as another embodiment of the present invention. The cross-linked ***thiol*** ester composition includes ***thiol*** ester oligomers having at least two ***thiol*** ester monomers connected by a polysulfide linkage having a structure -- S.sub.Q-- , wherein Q is greater than 1. In some embodiments, the

thiol
 ester oligomers have at least three ***thiol*** ester
 monomers
 connected by polysulfide linkages. In another aspect, the
 thiol
 ester oligomers have from 3 to 20 ***thiol*** ester monomers
 connected by polysulfide linkages.

SUMM In an aspect, the cross-linked ***thiol*** ester composition
 includes both ***thiol*** ester monomers and ***thiol***
 ester
 oligomers. In some embodiments, the ***thiol*** ester
 monomers and
 thiol ester oligomers have a total ***thiol***
 sulfur
 content ranging from 0.5 to 8 weight percent; or alternatively,
 ranging
 from 8 to 15 weight percent. The combined ***thiol*** ester
 monomers
 and ***thiol*** ester oligomers can have an average molecular
 weight
 greater than 2000; or alternatively, in a range from 2000 to
 20,000.

SUMM As another embodiment of the present invention, a cross-linked
 thiol ester composition produced by the process
 comprising the
 steps of contacting the ***thiol*** ester composition with an
 oxidizing agent and reacting the ***thiol*** ester and the
 oxidizing
 agent to form ***thiol*** ester oligomers is advantageously
 provided. In this embodiment, the ***thiol*** ester oligomers
 have
 at least two ***thiol*** ester monomers connected by a
 polysulfide
 linkage having a structure --S.sub.Q--, wherein Q is greater than
 1.

SUMM A process to produce the cross-linked ***thiol*** ester
 composition
 is also advantageously provided as another embodiment of the
 present
 invention. In this process, a ***thiol*** ester composition
 is
 contacted and reacted with an oxidizing agent to form
 thiol
 ester oligomers having at least two ***thiol*** ester
 monomers
 connected by a polysulfide linkage having a structure --
 S.sub.Q--,
 wherein Q is greater than 1. In some embodiments, the oxidizing
 agent is
 elemental sulfur, oxygen, or hydrogen peroxide. In an aspect, the
 oxidizing agent is elemental sulfur.

SUMM In an aspect, the ***thiol*** ester is a hydroxy
 thiol
 ester. In other aspects, a weight ratio of elemental sulfur to
 thiol sulfur in the ***thiol*** ester molecules
 ranges from

0.5 to 32.

SUMM The step of the reacting the ***thiol*** ester and the oxidizing agent can be performed at a temperature ranging from 25.degree. C. to 150.degree. C. The process for producing the cross-linked ***thiol*** ester composition can also include the step of stripping residual hydrogen sulfide from the cross-linked ***thiol*** ester composition produced. In another aspect, the reaction of the ***thiol*** ester and the elemental sulfur is catalyzed. In some embodiments, the catalyst is an amine.

SUMM In another of its aspects, the present invention relates to a controlled release fertilizer material comprising a particulate plant nutrient surrounded by a coating which is the reaction product of a mixture comprising: (i) a first component selected from an isocyanate and/or an epoxy resin, and (ii) a first active hydrogen-containing compound selected from the group consisting of: a ***thiol*** ester composition; a hydroxy ***thiol*** ester composition; a cross-linked ***thiol*** ester composition and mixtures thereof.

SUMM In another of its aspects, the present invention relates to a process for the production of abrasion resistant polythiourethane and/or epoxy polymer encapsulated controlled release fertilizer particles by incorporating in urethane and/or epoxy polymer forming reaction mixture a sulfur-containing compound such as one or more of a ***thiol*** ester composition; a hydroxy ***thiol*** ester composition; a cross-linked ***thiol*** ester composition, other sulfur-based compounds described herein below and mixtures thereof.

SUMM Preferably, for the production of the present polythiourethane encapsulated controlled release fertilizer material, a sulfur-containing compound (e.g., one or more of a ***thiol*** ester composition; a hydroxy ***thiol*** ester composition; a cross-linked ***thiol*** ester composition) is used as one of the isocyanate-reactive components (alone or in combination with other active hydrogen-containing compounds). Preferably, the sulfur-containing compound comprises a sulfur-containing vegetable oil. In one preferred embodiment, the sulfur-containing vegetable oil comprises a mercaptanized

vegetable oil
(MVO), more preferably as described in more detail herein, even
more preferably an MVO produced by the addition of hydrogen sulfide to
a vegetable oil. In another preferred embodiment, the sulfur-
containing vegetable oil comprises mercapto-hydroxy vegetable oil (MHVO),
more preferably as described in more detail herein, even more
preferably an MHVO produced by the addition of hydrogen sulfide to epoxidized
vegetable oil. In yet another preferred embodiment, the sulfur
containing vegetable oil comprises sulfur cross-linked
mercaptanized vegetable oil (CMVO), more preferably as described in more detail
herein, even more preferably an CMVO produced by the addition of
elemental sulfur to mercaptanized vegetable oil (MVO).

SUMM Preferably, for the production of epoxy polymer encapsulated
controlled release fertilizer material, a sulfur-containing compound (e.g.,
one or more of a ***thiol*** ester composition; a hydroxy
thiol ester composition; a cross-linked ***thiol*** ester
composition) is used as one of the isocyanate-reactive components (alone or in
combination with other active hydrogen-containing compounds).
Preferably, the sulfur-containing compound comprises a sulfur-
containing vegetable oil (e.g., MVO and/or MHVO and/or CMVO) is used as one
of the epoxy resin-reactive components.

DRWD FIG. 1 includes two graphs that compare the NMR's of soybean
oil, which is shown in the top graph, and a ***thiol*** containing ester
produced from soybean oil in accordance with an embodiment of the
present invention, which is shown in the bottom graph;

DRWD FIG. 2 includes two graphs that compare the NMR's of epoxidized
soybean oil, which is shown in the top graph, and a ***thiol***
containing ester produced from epoxidized soybean oil in accordance with an
embodiment of the present invention, which is shown in the bottom
graph;

DRWD FIG. 3 is a gas chromatograph (GC)/mass spectrometer (MS) trace
of a ***thiol*** containing ester that was produced from soybean
oil in accordance with an embodiment of the present invention and then
treated by methanolysis;

DRWD FIG. 5 is a GC/MS trace of hydroxy ***thiol*** containing
ester produced from epoxidized soybean oil in accordance with an
embodiment of

the present invention and then treated by methanolysis;
DETD In this specification, " ***thiol*** ester composition"

refers to an ester composition that includes " ***thiol*** ester molecules." The ***thiol*** ester molecule has at least one ***thiol*** group and at least one ester group within the ***thiol*** ester molecule.

DETD In this specification, "hydroxy ***thiol*** ester composition" refers to an ester composition that includes "hydroxy ***thiol*** ester molecules." The hydroxy ***thiol*** ester molecule has at least one ***thiol*** group, at least one ester group, and at least one hydroxy or alcohol group within the hydroxy ***thiol*** ester molecule. Alternatively, the alcohol group and the ***thiol*** group can be combined in the same group, which is referred to as an ".alpha.-hydroxy ***thiol*** group."

DETD In this specification, "polythiourethane" refers to a urethane composition that includes more than one of the following structure:

##STR1## The presence of the thiourethane group can be determined by method known to those skilled in the art (for example infrared spectroscopy, Raman spectroscopy, and/or NMR). ***Thiol***

Ester Composition

DETD The present invention advantageously provides a ***thiol*** ester composition as an embodiment of the present invention. The ***thiol*** ester composition includes ***thiol*** ester molecules that have an average of at least 1.5 ester groups and an average of at least 1.5 ***thiol*** groups per ***thiol*** ester molecule. The ***thiol*** ester composition also has a molar ratio of cyclic sulfides to ***thiol*** groups of less than 1.5, as described herein.

DETD Generally, the ***thiol*** ester composition contains molecules having at least one ester group and at least one ***thiol*** group.

The ***thiol*** ester composition of this invention can be produced from any unsaturated ester, as described herein. Because the feedstock unsaturated esters can contain multiple carbon-carbon double bonds per unsaturated ester molecule, carbon-carbon double bond reactivity and statistical probability dictate that each ***thiol*** ester molecule of the ***thiol*** ester composition produced from the unsaturated ester composition will not have the same number of ***thiol***

groups, number of unreacted carbon-carbon double bonds, number of cyclic sulfides, molar ratio of carbon-carbon double bonds to ***thiol*** groups, molar ratio of cyclic sulfides to ***thiol*** groups and other quantities of functional groups and molar ratios disclosed herein as the feedstock unsaturated ester. Additionally, the feedstock unsaturated esters can also comprise a mixture of individual esters having a different number of carbon-carbon double bonds and/or ester groups. Thus, many of these properties will be discussed as an average number of the groups per ***thiol*** ester molecule within the ***thiol*** ester composition or average ratio per ***thiol*** ester molecule within the ***thiol*** ester composition. In other embodiments, it is desired to control the content of ***thiol*** sulfur present in the ***thiol*** ester. Because it is difficult to ensure that the hydrogen sulfide reacts with every carbon-carbon double bond within the unsaturated ester, certain molecules of ***thiol*** ester can have more or less ***thiol*** groups than other molecules. Thus, the weight percent of ***thiol*** groups is stated as an average across all ***thiol*** ester molecules of the ***thiol*** ester composition.

DETD The ***thiol*** ester can be derived from any unsaturated ester described herein.

DETD The ***thiol*** ester compositions can be described as comprising one or more separate or discreet functional groups of the ***thiol*** ester molecule and/or ***thiol*** ester composition. These independent functional groups can include: the number of (or average number of) ester groups per ***thiol*** ester molecule, ***thiol*** containing the number of (or average number of) ***thiol*** groups per ***thiol*** ester molecule, the number of (or average number of) unreacted carbon-carbon double bonds per ***thiol*** ester molecule, the average ***thiol*** sulfur content of the ***thiol*** ester composition, the percentage (or average percentage) of sulfide linkages per ***thiol*** ester molecule, and the percentage (or average percentage) of cyclic sulfide groups per ***thiol*** ester molecule. Additionally, the ***thiol***

ester compositions can be described using individual or a combination of ratios including the ratio of double bonds to *****thiol***** groups, the ratio of cyclic sulfides to *****mercaptan***** group, and the like. As separate elements, these functional groups of the *****thiol***** composition will be described separately.

DETD Minimally, in some embodiments, the *****thiol***** ester contains *****thiol***** ester molecules having at least one ester group and one *****thiol***** group per *****thiol***** ester molecule. As the *****thiol***** ester is prepared from unsaturated esters, the *****thiol***** ester can contain the same number of ester groups as the unsaturated esters described herein. In an embodiment, the *****thiol***** ester molecules have an average of at least 1.5 ester groups per *****thiol***** ester molecule. Alternatively, the *****thiol***** ester molecules have an average of at least 2 ester groups per *****thiol***** ester molecule; alternatively, an average of at least 2.5 ester groups per *****thiol***** ester molecule; or alternatively, an average of at least 3 ester groups per *****thiol***** ester molecule. In other embodiments, the *****thiol***** esters have an average of from 1.5 to 8 ester groups per *****thiol***** ester molecule; alternatively, an average of from 2 to 7 ester groups per *****thiol***** ester molecule; alternatively, an average of from 2.5 to 5 ester groups per *****thiol***** ester molecule; or alternatively, an average of from 3 to 4 ester groups per *****thiol***** ester molecule. In yet other embodiments, the *****thiol***** ester comprises an average of 3 ester groups per *****thiol***** ester molecule or alternatively, an average of 4 ester groups per unsaturated ester molecule.

DETD Minimally, the *****thiol***** ester comprises an average of at least one *****thiol***** group per *****thiol***** ester molecule. In an embodiment, the *****thiol***** ester molecules have an average of at least 1.5 *****thiol***** groups per *****thiol***** ester molecule; alternatively, *****thiol***** containing an average of at least 2 *****thiol***** groups per *****thiol***** ester molecule; alternatively, an average of at least 2.5 *****thiol***** groups per *****thiol***** ester molecule; or alternatively, an average of at least 3

thiol
 groups per ***thiol*** ester molecule. In other embodiments,
 the ***thiol*** ester molecules have an average of from 1.5 to 9
 thiol groups per ***thiol*** ester molecule;
 alternatively,
 an average of from 3 to 8 ***thiol*** groups per
 thiol
 ester molecule; alternatively, ***thiol*** containing an
 average of
 from 2 to 4 ***thiol*** groups per ***thiol*** ester
 molecule,
 or alternatively, an average of from 4 to 8 ***thiol***
 groups per
 thiol ester molecule.
 DETD In other embodiments, the ***thiol*** ester can be described
 by the average amount of ***thiol*** sulfur present in ***thiol***
 ester. In an embodiment, the ***thiol*** ester molecules have
 an
 average of at least 5 weight percent ***thiol*** sulfur per
 thiol ester molecule; alternatively, an average of at
 least 10
 weight percent ***thiol*** sulfur per ***thiol*** ester
 molecule, or alternatively, an average of greater than 15 weight
 percent
 thiol sulfur per ***thiol*** ester molecule. In an
 embodiment, the ***thiol*** ester molecules have an average
 of from
 5 to 25 weight percent ***thiol*** sulfur per ***thiol***
 ester
 molecule; alternatively, an average of from 5 to 20 weight
 percent
 thiol sulfur per ***thiol*** ester molecule;
 alternatively,
 an average of from 6 to 15 weight percent ***thiol*** sulfur
 per
 thiol ester molecule; or alternatively, an average of
 from 8 to
 10 weight percent ***thiol*** sulfur per ***thiol***
 ester
 molecule.
 DETD Generally, the location of the ***thiol*** group of the
 thiol ester is not particularly important and will be
 dictated
 by the method used to produce the ***thiol*** ester. In
 embodiments
 wherein the ***thiol*** ester is produced by contacting an
 unsaturated ester, the position of the ***thiol*** group will
 be
 dictated by the position of the carbon-carbon double bond. When
 the
 carbon-carbon double bond is an internal carbon-carbon double
 bond, the
 method of producing the ***thiol*** ester will result in a
 secondary
 thiol group. However, when the double bond is located
 at a
 terminal position it is possible to choose reaction conditions to
 produce a ***thiol*** ester comprising either a primary

DETD ***thiol*** group or a secondary ***thiol*** group.
 can Some methods of producing the ***thiol*** ester composition

additionally create sulfur containing functional groups other than a

thiol group. For example, in some ***thiol*** ester production methods, an introduced ***thiol*** group can react with a

carbon-carbon double bond within the same unsaturated ester to produce a

sulfide linkage. When the reaction is with a double bond of a second

unsaturated ester, this produces a simple sulfide linkage. However, in

some instances, the second carbon-carbon double bond is located in the

same unsaturated ester molecule. When the ***thiol*** group reacts

with a second carbon-carbon double bond within the same unsaturated

ester molecule, a sulfide linkage is produced. In some instances, the

carbon-carbon double bond can be within a second ester group of the

unsaturated ester molecule. While in other instances, the carbon-carbon

double bond can be within the same ester group of the unsaturated ester

molecule.

DETD When the ***thiol*** group reacts with the carbon-carbon

double bond in a second ester group of the same unsaturated ester

molecule, the

cyclic sulfide would contain two ester groups contained within a

ring structure. When the ***thiol*** group reacts with the carbon-

carbon double bond within the same ester group, the cyclic sulfide would

not contain an ester group within the ring structure. Within this

as a specification, this second type of cyclic sulfide is referred to

cyclic as a cyclic sulfide. Within this specification, the first type of

sulfide sulfide is referred to as a simple sulfide. In the cyclic sulfide

case, the sulfide linkage produces a cyclic sulfide functionality

within a single ester group of the ***thiol*** ester. This linkage is

termed a cyclic sulfide for purposes of this application. One such

sulfide group that can be produced is a cyclic sulfide. The cyclic

sulfide rings

that can be produced include a tetrahydrothiopyran ring, a

thietane ring, or a thiophane ring (tetrahydrothiophene ring).

DETD In some embodiments, it is desirable to control the average

amount of sulfur present as cyclic sulfide in the ***thiol*** ester. In

an embodiment the average amount of sulfur present as cyclic sulfide in the ***thiol*** ester molecules comprises less than 30 mole percent. Alternatively, the average amount of sulfur present as cyclic sulfide in the ***thiol*** esters comprises less than 20 mole percent; alternatively, less than 10 mole percent; alternatively, less than 5 mole percent; or alternatively, less than 2 mole percent. In other embodiments, it is desired to control the molar ratio of cyclic sulfides to ***thiol*** groups. In other embodiments, it is desirable to have molar ratios of cyclic sulfide to ***thiol*** group. In an embodiment, the average molar ratio of cyclic sulfide groups to ***thiol*** group per ***thiol*** ester is less than 1.5. Alternatively, the average molar ratio of cyclic sulfide groups to ***thiol*** group per ***thiol*** ester is less than 1; alternatively, less than 0.5; alternatively, less than 0.25; or alternatively, 0.1. In some embodiments, the ratio of cyclic sulfide groups to ***thiol*** group per ***thiol*** ester ranges from 0 to 1; or alternatively, the average molar ratio of cyclic sulfide groups to ***thiol*** group per ***thiol*** ester ranges between 0.05 and 1.

DETD In some instances it can be desirable to have carbon-carbon double bonds present in the ***thiol*** ester composition while in other embodiments it can be desirable to minimize the number of carbon-carbon double bonds present in the ***thiol*** ester composition.

The presence of carbon-carbon double bonds present in the ***thiol*** ester can be stated as an average molar ratio of carbon-carbon double bonds to ***thiol*** -sulfur. In an embodiment, the average ratio of the remaining unreacted carbon-carbon double bond in the ***thiol*** ester composition to ***thiol*** sulfur is less than 1.5 per ***thiol*** ester molecule. Alternatively, the average ratio of carbon-carbon double bond to ***thiol*** sulfur is less than 1.2 per ***thiol*** ester molecule; alternatively, less than 1.0 per ***thiol*** ester molecule; alternatively, less than 0.75 per ***thiol*** ester molecule; alternatively, less than 0.5 per ***thiol*** ester molecule; alternatively, less than 0.2 per ***thiol*** ester molecule; or alternatively, less than 0.1 per ***thiol*** ester molecule.

DETD In particular embodiments, the ***thiol*** ester is produced

from unsaturated ester compositions. Because the feedstock unsaturated ester has particular compositions having a certain number of ester groups present, the product ***thiol*** ester composition will have about the same number of ester groups per ***thiol*** ester molecule as the feedstock unsaturated ester. Other, independent ***thiol*** ester properties described herein can be used to further describe the ***thiol*** ester composition.

DETD In some embodiments, the ***thiol*** ester molecules are produced from unsaturated esters having an average of less than 25 weight percent of side chains having 3 contiguous methylene interrupted carbon-carbon double bonds, as described herein. In some embodiments, greater than 40 percent of the ***thiol*** containing natural source total side chains can include sulfur. In some embodiments, greater than 60 percent of the ***thiol*** ester molecule total side chains can include sulfur. In other embodiments, greater than 50, 70, or 80 percent of the ***thiol*** ester molecule total side chains can include sulfur.

DETD In an embodiment, the ***thiol*** ester is a ***thiol*** containing natural source oil, as described herein. When the ***thiol*** ester is a ***thiol*** containing natural source oil, functional groups that are present in the ***thiol*** containing natural source oil can be described in a "per ***thiol*** ester molecule" basis or in a "per triglyceride" basis. The ***thiol*** containing natural source oil can have substantially the same properties as the ***thiol*** ester composition, such as the molar ratios and other independent descriptive elements described herein.

DETD The average number of ***thiol*** groups per triglyceride in the ***thiol*** containing natural source oil is greater than about 1.5.

In some embodiments, the average number of ***thiol*** groups per triglyceride can range from about 1.5 to about 9.

DETD The ***thiol*** ester compositions can also be described as a product produced by the process comprising contacting hydrogen sulfide and an unsaturated ester composition and can be further limited by the process as described herein. The ***thiol*** containing

natural source oil can also be described using a molecular weight or an average molecular weight of the side chains.

DETD Hydroxy ***Thiol*** Ester Composition

DETD In embodiments of the present invention, the ***thiol*** ester compositions can also contain a hydroxy or alcohol group. When the ***thiol*** ester composition includes the hydroxy group, the ***thiol*** ester composition is referred to herein as the hydroxy ***thiol*** ester composition. The quantity or number of alcohol groups present in the hydroxy ***thiol*** ester composition can be independent of the quantity of other functional groups present in the hydroxy ***thiol*** ester composition (i.e. ***thiol*** ester groups, sulfides, cyclic sulfides). Additionally, the weight percent of ***thiol*** sulfur and functional group ratios (i.e. molar ratio of cyclic sulfides to ***thiol*** groups, molar ratio of ***epoxide*** groups to ***thiol*** groups, molar ratio of ***epoxide*** groups to .alpha.-hydroxy ***thiol*** groups and other disclosed quantities of functional groups and their molar ratios to the ***thiol*** groups) are separate or discreet elements that can be used to describe the hydroxy ***thiol*** ester composition. The hydroxy ***thiol*** ester composition can be described using any combination of the hydroxy ***thiol*** ester composition separate functional groups or ratios described herein.

DETD In an embodiment, the hydroxy ***thiol*** ester composition is produced by reacting hydrogen sulfide with an epoxidized unsaturated ester composition as described herein. Because the epoxidized unsaturated ester can contain multiple ***epoxide*** groups, ***epoxide*** group reactivity and statistical probability dictate that not all hydroxy ***thiol*** ester molecules of the hydroxy ***thiol*** ester composition will have the same number of hydroxy groups, ***thiol*** groups, .alpha.-hydroxy ***thiol*** groups, sulfides, cyclic sulfides, molar ratio of cyclic sulfides to ***thiol*** groups, molar ratio of ***epoxide*** groups to ***thiol*** groups, molar ratio of ***epoxide*** groups to

.alpha.-hydroxy ***thiol*** groups, weight percent
thiol sulfur and other disclosed quantities of functional groups and
their molar ratios as the epoxidized unsaturated ester composition.
Thus, many of these properties will be discussed as an average number or
ratio per hydroxy ***thiol*** ester molecule. In other embodiments, it
is desired to control the content of ***thiol*** sulfur present
in the hydroxy ***thiol*** ester. Because it is difficult to ensure
that the hydrogen sulfide reacts with every ***epoxide*** group
within the epoxidized unsaturated ester, certain hydroxy ***thiol***
ester molecules can have more or less ***thiol*** groups than other
molecules within the hydroxy ***thiol*** ester composition.
Thus, the weight percent of ***thiol*** groups can be stated as an
average weight percent across all hydroxy ***thiol*** ester
molecules.
DETD As an embodiment of the present invention, the hydroxy
thiol ester composition includes hydroxy ***thiol*** ester
molecules that have an average of at least 1 ester groups and an average of at
least 1 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol***
ester molecule. As an embodiment of the present invention, the hydroxy
thiol ester composition includes hydroxy ***thiol***
ester molecules that have an average of at least 1.5 ester groups and
an average of at least 1.5 .alpha.-hydroxy ***thiol*** groups
per hydroxy ***thiol*** ester molecule.
DETD Minimally, in some embodiments, the hydroxy ***thiol***
ester comprises at least one ester, at least one ***thiol*** group,
and at least one hydroxy group. Because the hydroxy ***thiol***
ester is prepared from epoxidized unsaturated esters, the hydroxy
thiol ester can contain the same number of ester groups as the
epoxidized unsaturated esters. In an embodiment, the hydroxy ***thiol***
ester molecules have an average of at least 1.5 ester groups per
hydroxy ***thiol*** ester molecule. Alternatively, the hydroxy
thiol ester molecules have an average of at least 2 ester groups per
hydroxy ***thiol*** ester molecule; alternatively, an average of at

least 2.5
 ester groups per hydroxy ***thiol*** ester molecule; or
 alternatively, an average of at least 3 ester groups per hydroxy
 thiol ester molecule. In other embodiments, the hydroxy
 thiol esters have an average of from 1.5 to 8 ester
 groups per
 hydroxy ***thiol*** ester molecule; alternatively, an average
 of
 from 2 to 7 ester groups per hydroxy ***thiol*** ester
 molecule;
 alternatively, an average of from 2.5 to 5 ester groups per
 hydroxy
 thiol ester molecule; or alternatively, an average of
 from 3 to
 4 ester groups per hydroxy ***thiol*** ester molecule. In yet
 other
 embodiments, the .alpha.-hydroxy ***thiol*** ester comprises
 an
 average of 3 ester groups per hydroxy ***thiol*** ester
 molecule or
 alternatively, an average of 4 ester groups per hydroxy
 thiol
 ester molecule.
 DETD In some embodiments, the hydroxy group and the ***thiol***
 group
 are combined in the same group, which produces the .alpha.-
 hydroxy
 thiol group. In other embodiments, the ***thiol***
 group and
 the hydroxy or alcohol group are not in the same group. When this
 occurs, to produce the hydroxy ***thiol*** ester composition,
 the
 alcohol group is added independently of the ***thiol***
 group. For
 example, as another embodiment of the present invention, the
 hydroxy
 thiol ester composition advantageously includes hydroxy
 thiol ester molecules. The hydroxy ***thiol***
 ester
 molecules have an average of at least 1.5 ester groups, an
 average of at
 least 1.5 ***thiol*** groups, and an average of at least 1.5
 alcohol
 groups per hydroxy ***thiol*** ester molecule.
 DETD Minimally, in some embodiments, the hydroxy ***thiol***
 ester
 comprises at least one ***thiol*** group per hydroxy
 thiol
 ester molecule. In an embodiment, the hydroxy ***thiol***
 ester
 molecules have an average of at least 1.5 ***thiol*** groups
 per
 hydroxy ***thiol*** ester molecule; alternatively, an average
 of at
 least 2 ***thiol*** groups per hydroxy ***thiol*** ester
 molecule; alternatively, an average of at least 2.5 ***thiol***
 groups per hydroxy ***thiol*** ester molecule; or
 alternatively, an
 average of at least 3 ***thiol*** groups per hydroxy
 thiol

ester molecule. In other embodiments, the hydroxy ***thiol*** ester molecules have an average of from 1.5 to 9 ***thiol*** groups per hydroxy ***thiol*** ester molecule; alternatively, an average of from 3 to 8 ***thiol*** groups per hydroxy ***thiol*** ester molecule; alternatively, an average of from 2 to 4 ***thiol*** groups per hydroxy ***thiol*** ester molecule; or alternatively, an average of from 4 to 8 ***thiol*** groups per hydroxy ***thiol*** ester.

DETD Minimally, in some embodiments, the hydroxy ***thiol*** ester composition comprises an average of at least 1 hydroxy or alcohol group per hydroxy ***thiol*** ester molecule. In some embodiments, the hydroxy ***thiol*** ester composition comprises an average of at least 1.5 hydroxy groups per hydroxy ***thiol*** ester molecule; alternatively, average of at least 2 hydroxy groups per hydroxy ***thiol*** ester molecule; alternatively, an average of at least 2.5 hydroxy groups per hydroxy ***thiol*** ester molecule; or alternatively, an average of at least 3 hydroxy groups per ***thiol*** ester molecule. In other embodiments, the ***thiol*** ester composition comprises an average of from 1.5 to 9 hydroxy groups per hydroxy ***thiol*** ester molecule; alternatively, an average of from 3 to 8 hydroxy groups per hydroxy ***thiol*** ester molecule; alternatively, an average of from 2 to 4 hydroxy groups per hydroxy ***thiol*** ester molecule; or alternatively, an average of from 4 to 8 hydroxy groups per hydroxy ***thiol*** ester molecule.

DETD In yet other embodiments, the number of hydroxy groups can be stated as an average molar ratio of hydroxy group to ***thiol*** groups. Minimally, in some embodiments, the molar ratio of hydroxy groups to ***thiol*** groups is at least 0.25. In some embodiments, the molar ratio of hydroxy groups to ***thiol*** groups is at least 0.5; alternatively, at least 0.75; alternatively, at least 1.0; alternatively, at least 1.25; or alternatively, at least 1.5. In other embodiments, the molar ratio of hydroxy groups to ***thiol*** groups ranges from 0.25 to 2.0; alternatively, from 0.5 to 1.5; or alternatively, from 0.75 to 1.25.

DETD In embodiments where the hydroxy ***thiol*** esters are

produced from an epoxidized unsaturated ester, the hydroxy *****thiol***** esters can be described as containing ester groups and .alpha.-hydroxy *****thiol***** groups. The number of ester groups and the number of .alpha.-hydroxy *****thiol***** groups are independent elements and as such the hydroxy *****thiol***** esters can be described as having any combination of ester groups and .alpha.-hydroxy *****thiol***** groups described herein. Minimally, the hydroxy *****thiol***** ester comprises an average of at least 1 .alpha.-hydroxy *****thiol***** group per hydroxy *****thiol***** ester molecule. In some embodiments, the hydroxy *****thiol***** ester composition comprises an average of at least 1.5 .alpha.-hydroxy *****thiol***** groups per hydroxy *****thiol***** ester molecule; alternatively, an average of at least 2 .alpha.-hydroxy *****thiol***** groups per hydroxy *****thiol***** ester molecule; alternatively, an average of at least 2.5 .alpha.-hydroxy *****thiol***** groups per hydroxy *****thiol***** ester molecule; or alternatively, an average of at least 3 .alpha.-hydroxy *****thiol***** groups per hydroxy *****thiol***** ester molecule. In other embodiments, the hydroxy *****thiol***** ester composition comprises an average of from 1.5 to 9 .alpha.-hydroxy *****thiol***** groups per hydroxy *****thiol***** ester molecule; alternatively, an average of from 3 to 8 .alpha.-hydroxy *****thiol***** groups per hydroxy *****thiol***** ester molecule; alternatively, an average of from 2 to 4 .alpha.-hydroxy *****thiol***** groups per hydroxy *****thiol***** ester molecule; or alternatively, an average of from 4 to 8 .alpha.-hydroxy *****thiol***** groups per hydroxy *****thiol***** ester molecule.

DETD The hydroxy *****thiol***** esters can be produced by contacting an epoxidized ester derived from an unsaturated ester (i.e., epoxidized unsaturated ester), as described herein. In some instances it can be desirable to have *****epoxide***** groups present in the hydroxy *****thiol***** ester composition. While in other embodiments, it can be desirable to minimize the number of epoxy groups present in the hydroxy *****thiol***** ester composition. Thus, the presence of residual *****epoxide***** groups can be another separate functional group used to describe the hydroxy *****thiol***** ester.

DETD The presence of ***epoxide*** groups in the hydroxy
 thiol
 ester can be independently described as an average number of
 epoxide groups per hydroxy ***thiol*** ester, a
 molar ratio
 of ***epoxide*** groups to ***thiol*** groups, a molar
 ratio of
 epoxide groups to .alpha.-hydroxy ***thiol***
 groups, or any
 combination thereof. In some embodiments, the hydroxy
 thiol
 ester molecules comprise an average of less than 2
 epoxide
 groups per hydroxy ***thiol*** ester molecule, i.e., the
 hydroxy
 thiol ester molecules have a molar ratio of
 epoxide
 groups to .alpha.-hydroxy ***thiol*** groups of less than 2.
 Alternatively, the hydroxy ***thiol*** ester comprises an
 average of
 less than 1.5 ***epoxide*** groups per hydroxy ***thiol***
 ester
 molecule; alternatively, an average of less than 1
 epoxide
 group per hydroxy ***thiol*** ester molecule; alternatively,
 an
 average of less than 0.75 ***epoxide*** groups per hydroxy
 thiol ester molecule; or alternatively, an average of
 less than
 0.5 ***epoxide*** groups per hydroxy ***thiol*** ester
 molecule.
 In other embodiments, the molar ratio of ***epoxide*** groups
 to
 thiol groups averages less than 1.5. Alternatively, the
 molar
 ratio of ***epoxide*** groups to ***thiol*** groups
 averages
 less than 1; alternatively, averages less than 0.75;
 alternatively,
 averages less than 0.5; alternatively, averages less than 0.25;
 or
 alternatively, averages less than 0.1. In yet other embodiments,
 the
 molar ratio of ***epoxide*** groups to .alpha.-hydroxy
 thiol
 groups averages less than 1.5. Alternatively, the molar ratio of
 epoxide groups to .alpha.-hydroxy ***thiol***
 groups
 averages less than 1; alternatively, averages less than 0.75;
 alternatively, averages less than 0.5; alternatively, averages
 less than
 0.25; or alternatively, averages less than 0.1.
 DETD In some embodiments, the hydroxy ***thiol*** ester
 composition is
 substantially free of ***epoxide*** groups.
 DETD In other embodiments, the hydroxy ***thiol*** ester can be
 described by the average amount of ***thiol*** sulfur present
 in
 hydroxy ***thiol*** ester. In an embodiment, the hydroxy
 thiol ester molecules have an average of at least 2.5

weight percent ***thiol*** sulfur per hydroxy ***thiol*** ester molecule; alternatively, an average of at least 5 weight percent ***thiol*** sulfur per hydroxy ***thiol*** ester molecule; alternatively, an average of at least 10 weight percent ***thiol*** sulfur per hydroxy ***thiol*** ester molecule; or alternatively, an average of greater than 15 weight percent ***thiol*** sulfur per hydroxy ***thiol*** ester molecule. In an embodiment, the ***thiol*** ester molecules have an average of from 5 to 25 weight percent ***thiol*** sulfur per hydroxy ***thiol*** ester molecule; alternatively, an average of from 5 to 20 weight percent ***thiol*** sulfur per hydroxy ***thiol*** ester molecule; alternatively, an average of from 6 to 15 weight percent ***thiol*** sulfur per hydroxy ***thiol*** ester molecule; or alternatively, an average of from 8 to 10 weight percent ***thiol*** sulfur per hydroxy ***thiol*** ester molecule.

DETD In some embodiments, at least 20 percent of the total side chains include the .alpha.-hydroxy ***thiol*** group. In some embodiments, at least 20 percent of the total side chains include the .alpha.-hydroxy ***thiol*** group. In some embodiments, at least 60 percent of the total side chains include the .alpha.-hydroxy ***thiol*** group; alternatively, at least 70 percent of the total side chains include the .alpha.-hydroxy ***thiol*** group. Yet in other embodiments, at least 80 percent of the total side chains include the .alpha.-hydroxy ***thiol*** group.

DETD In some aspects, greater than 20 percent of the hydroxy ***thiol*** ester molecule total side chains contain sulfur. In some aspects, greater than 40 percent of the hydroxy ***thiol*** ester molecule total side chains contain sulfur. In some aspects, greater than 60 percent of the hydroxy ***thiol*** ester molecule total side chains contain sulfur; alternatively, greater than 70 percent of the total side chains contain sulfur; or alternatively, greater than 80 percent of the total side chains contain sulfur.

DETD In particular embodiments, the epoxidized unsaturated ester used in the synthesis of the hydroxy ***thiol*** ester is produced from

the epoxidized unsaturated ester composition that includes an epoxidized natural source oil. Because the natural source oils have particular compositions regarding the number of ester groups present, the hydroxy ***thiol*** ester will have about the same number of ester groups as the feedstock natural source oil. Other independent properties that are described herein can be used to further describe the hydroxy ***thiol*** ester.

DETD In other embodiments, the epoxidized unsaturated ester used to produce the hydroxy ***thiol*** ester is produced from synthetic (or semi-synthetic) unsaturated ester oils. Because the synthetic ester oils can have particular compositions regarding the number of ester groups present, the hydroxy ***thiol*** ester would have about the same number of ester groups as the synthetic ester oil. Other, independent properties of the unsaturated ester, whether the unsaturated ester includes natural source or synthetic oils, can be used to further describe the hydroxy ***thiol*** ester composition.

DETD The hydroxy ***thiol*** ester compositions can also be described as a product produced by the process comprising contacting hydrogen sulfide and an epoxidized unsaturated ester composition and can be further limited by the process as described herein. The hydroxy ***thiol*** containing natural source oil can also be described using an average molecular weight or an average molecular weight of the side chains.

DETD Cross-Linked ***Thiol*** Ester Compositions

DETD In an aspect, the present invention relates to a cross-linked ***thiol*** ester composition. Generally, the cross-linked ***thiol*** ester molecules are oligomers of ***thiol*** esters that are connected together by polysulfide linkages --S.sub.x-- wherein x is an integer greater 1. As the cross-linked ***thiol*** ester is described as an oligomer of ***thiol*** esters, the ***thiol*** esters can be described as the monomer from which the cross-linked ***thiol*** esters are produced.

DETD In an aspect, the cross-linked ***thiol*** ester composition comprises a ***thiol*** ester oligomer having at least two ***thiol*** ester monomers connected by a polysulfide linkage having a structure --S.sub.Q--, wherein Q is an integer greater than 1. In an

aspect, the polysulfide linkage may be the polysulfide linkage --S.sub.Q-- , wherein Q is 2, 3, 4, or mixtures thereof. In other embodiments, Q can be 2; alternatively, 3; or alternatively, 4.

DETD In an aspect, the cross-linked ***thiol*** ester composition comprises a ***thiol*** ester oligomer having at least 3 ***thiol*** ester monomers connected by polysulfide linkages; alternatively, 5 ***thiol*** ester monomers connected by polysulfide linkages; alternatively, 7 ***thiol*** ester monomers connected by polysulfide linkages; or alternatively, 10 ***thiol*** ester monomers connected by polysulfide linkages. In yet other embodiments, the cross-linked ***thiol*** ester composition comprises a ***thiol*** ester oligomer having from 3 to 20 ***thiol*** ester monomers connected by polysulfide linkages; alternatively, from 5 to 15 ***thiol*** ester monomers connected by polysulfide linkages; or alternatively, from 7 to 12 ***thiol*** ester monomers connected by polysulfide linkages.

DETD In an aspect, the cross-linked ***thiol*** ester composition comprises ***thiol*** ester monomers and ***thiol*** ester oligomers. In some embodiments, the cross-linked ***thiol*** ester composition has a combined ***thiol*** ester monomer and ***thiol*** ester oligomer average molecular weight greater than 2,000. In other embodiments, the cross-linked ***thiol*** ester composition has a combined ***thiol*** ester monomer and ***thiol*** ester oligomer average molecular weight greater than 5,000; or alternatively, greater than 10,000. In yet other embodiments, the cross-linked ***thiol*** ester composition has a combined ***thiol*** ester monomer and ***thiol*** ester oligomer average molecular weight ranging from 2,000 to 20,000; alternatively, from 3,000 to 15,000; or alternatively, from 7,500 to 12,500.

DETD In an aspect, the ***thiol*** ester monomers and ***thiol*** ester oligomers have a total ***thiol*** sulfur content greater than 0.5. In other embodiments, the ***thiol*** ester monomers and ***thiol*** ester oligomers have a total ***thiol*** sulfur content greater than 1; alternatively, greater than 2; alternatively, greater than 4. In yet other embodiments, the ***thiol*** ester monomers and the ***thiol*** ester oligomers have a total ***thiol*** sulfur content from 0.5 to 8; alternatively, from 4 to 8; or alternatively, 0.5 to 4.

DETD In an aspect, the ***thiol*** ester monomers and

thiol
ester oligomers have a total sulfur content greater than 8. In
some embodiments, the ***thiol*** ester monomers and ***thiol***
ester oligomers have a total sulfur content greater than 10;
alternatively, greater than 12. In yet other embodiments, the
thiol ester monomers and ***thiol*** ester
oligomers have a
total sulfur content ranging from 8 to 15 weight percent;
alternatively,
from 9 to 14; or alternatively, from 10 to 13.
DETD The cross-linked ***thiol*** ester compositions can also be
described as a product produced by the process comprising
contacting a
thiol ester with oxidizing agent and can be further
limited by
the process as described herein.
DETD The present invention advantageously includes sulfide-containing
ester compositions as embodiments of the present invention. Generally,
the sulfide-containing ester compositions can be described as
containing
molecules having at least one ester group and a least one sulfide
group within each molecule. The sulfide-containing esters used in the
present invention can be produced by contacting either an unsaturated
ester or
an epoxidized unsaturated ester with a ***thiol*** containing
compound as described herein.
DETD The feedstock unsaturated esters can contain multiple carbon-
carbon
double bonds per unsaturated ester molecule. The carbon-carbon
double bond reactivity and statistical probability, however, dictate
that each
sulfide-containing ester molecule of the ***thiol*** -
containing
ester composition produced from the unsaturated ester composition
will
not have the same number of sulfide groups, number of unreacted
carbon-carbon double bonds, molar ratio of carbon-carbon double
bonds to
sulfide groups, molar ratio of cyclic sulfides to ***thiol***
groups
and other herein disclosed quantities of functional groups and
molar
ratios. Additionally, the feedstock unsaturated esters can also
comprise
a mixture of individual unsaturated esters having a different
number of
carbon-carbon double bonds and/or ester groups. Many of these
properties
are discussed herein as an average number of the groups per
sulfide-containing ester molecule within the sulfide-containing
ester
composition or average ratio per ***thiol*** -containing ester
molecule within the sulfide-containing ester composition.
DETD In embodiments related to the sulfide-containing ester that is

produced from an epoxidized unsaturated ester, the feedstock epoxidized unsaturated esters can contain multiple ***epoxide*** groups per unsaturated ester molecule. Individual ***epoxide*** group reactivity and statistical probability dictate that each sulfide-containing ester molecule of the sulfide-containing ester composition produced from the unsaturated ester composition will not have the same number of sulfide groups, number of unreacted ***epoxide*** groups, molar ratio of ***epoxide*** groups to sulfide groups, and other herein disclosed quantities of functional groups and molar ratios. Additionally, the feedstock epoxidized unsaturated esters can also comprise a mixture of individual epoxidized unsaturated ester molecules having a different number of ***epoxide*** groups and/or ester groups. Thus, many of these properties are described as an average number of the groups per sulfide-containing ester molecules within the sulfide-containing ester composition or average ratio per ***thiol*** -containing ester molecule within the sulfide-containing ester composition.

DETD Minimally, in some embodiments, the sulfide-containing esters comprise at least one ester group per sulfide-containing ester molecule. In some embodiments, the sulfide-containing ester has an average of at least 1.5 ester groups per sulfide-containing ester molecule. Alternatively, the sulfide-containing ester molecules have an average of at least 2 ester groups per sulfide-containing ester molecule; alternatively, an average of at least 2.5 ester groups per sulfide-containing ester molecule; or alternatively, an average of at least 3 ester groups per sulfide-containing ester molecule. In other embodiments, the sulfide-containing esters have an average of from 1.5 to 9 ester groups per sulfide-containing ester molecule; alternatively, an average of from 1.5 to 8 ester groups per sulfide-containing ester molecule; alternatively, an average of from 2 to 8 ester groups per sulfide-containing ester molecule; alternatively, an average of from 2 to 7 ester groups per sulfide-containing ester molecule; alternatively, an average of from 2.5 to 5 ester groups per sulfide-containing ester molecule; alternatively, an average of from 3 to 5 ester groups per sulfide-containing ester molecule; or alternatively, an average of from 3 to 4 ester groups per sulfide-containing ester molecule. In yet other

embodiments, the hydroxy ***thiol*** -containing ester comprises an average of about 3 ester groups per sulfide-containing ester molecule; or alternatively, an average of about 4 ester groups per sulfide-containing ester molecule.

DETD In some embodiments, R.sup.3 comprises at least one functional group. In one aspect, the functional group is selected from the group consisting of a hydroxy group, a carboxylic acid group, a carboxylic ester group, an amine group, a sulfide group, and a second ***thiol*** group. In some aspects, R.sup.3 comprises at least two functional groups. In some aspects, the functional groups are selected from the group consisting of a hydroxy group, carboxylic acid group, a carboxylic ester group, an amine group, a sulfide group, a second ***thiol*** group, and mixtures thereof.

DETD The sulfide-containing ester compositions can also be described as a product produced by the process comprising contacting an unsaturated ester with a ***mercaptan*** and can be further limited by the process as described herein. In other embodiments, the sulfide-containing ester composition can also be described as a product produced by a process comprising contacting an epoxidized unsaturated ester with a ***mercaptan*** and can be further limited by the process as described herein.

DETD Generally, the thioacrylate ester composition can be described as comprising thioacrylate molecules having at least one ester group in addition to any acrylate or thioacrylate ester groups present in the thioacrylate molecule and at least one thioacrylate group. The ester group(s) that are in addition to any acrylate or thioacrylate ester groups present in the thioacrylate molecule are hereinafter referred to as "supplementary ester group(s)." The thioacrylate ester composition described herein can be produced by contacting an acrylate composition with a ***thiol*** -containing ester composition and/or a hydroxy ***thiol*** -containing ester composition, both of which are described herein.

DETD The feedstock ***thiol*** ester compositions and/or hydroxy ***thiol*** ester compositions can comprise a mixture of molecules that have an average quantity of ester groups, ***thiol***

groups, hydroxy groups, and other groups and molar ratios described herein. Additionally, individual ***thiol*** and hydroxy group reactivity within the ***thiol*** -containing ester compositions and/or hydroxy ***thiol*** ester compositions and statistical probability dictate that each thioacrylate ester molecule of the thioacrylate ester composition produced may not have the same number of ester groups, thioacrylate groups, acrylate groups, and other herein disclosed quantities of functional groups, moieties, and molar ratios. Thus, many of the properties of the thioacrylate ester molecules within the thioacrylate ester composition are described as using an average number of the groups per thioacrylate ester molecule within the thioacrylate ester composition or as an average ratio per thioacrylate ester molecule within the thioacrylate ester composition. DETD The thioacrylate ester can also be described as a product produced by the process that includes contacting a ***thiol*** -containing ester composition with an acrylate composition and can be further limited by the process described herein. In other embodiments, the thioacrylate ester composition can also be described as a product produced by a process that includes contacting a hydroxy ***thiol*** -containing ester composition with an acrylate composition and can be further limited by the process described herein. DETD The present invention advantageously provides a sulfonic acid-containing ester as an embodiment of the present invention. Generally, the sulfonic acid-containing ester of the present invention includes sulfonic acid-containing ester molecules having at least one ester group and a least one sulfonic acid group. The sulfonic acid-containing ester described herein can be produced by contacting a ***thiol*** ester with an oxidizing agent as described herein. Because the feedstock for the production of the sulfonic acid-containing ester can include multiple ***thiols*** groups, ***thiol*** group reactivity and statistical probability dictate that each sulfonic acid-containing ester molecule of the sulfonic acid-containing ester will not have the same number of sulfonic acid groups. Additionally, the feedstock ***thiol*** ester can also include a mixture of individual ***thiol*** ester molecules having different numbers of

thiol groups and/or ester groups. Thus, many of the groups present in the sulfonic acid-containing ester are described herein as an average number of the groups per sulfonic acid-containing ester molecule or an average ratio per sulfonic acid-containing ester molecule within the sulfonic acid-containing ester.

DETD In some embodiments of the present invention, the sulfonic acid ester is substantially free of ***thiol*** groups.

DETD The sulfonic acid-containing ester can also be described as a product produced by the process comprising contacting a ***thiol*** ester with an oxidizing agent described herein.

DETD Process for Making a ***Thiol*** Ester Composition

DETD The present invention advantageously provides processes for producing a ***thiol*** ester composition as embodiments of the present invention.

As an embodiment, the present invention advantageously includes a process to produce a ***thiol*** ester composition by contacting hydrogen sulfide and an unsaturated ester composition containing unsaturated esters and reacting the hydrogen sulfide and unsaturated esters to form or produce the ***thiol*** ester composition.

As another embodiment of the present invention, a process to produce the ***thiol*** ester composition is advantageously provided. In this embodiment, the process includes contacting a composition comprising a polyol with a composition comprising a ***thiol*** containing carboxylic acid composition and reacting the polyol and ***thiol*** containing carboxylic acid composition to form the ***thiol*** ester composition.

DETD In some embodiments of the present invention that include producing ***thiol*** ester compositions, the unsaturated ester composition is a natural source oil. In an aspect, the unsaturated ester composition is soybean oil or alternatively castor oil. Other suitable types of unsaturated ester compositions are described herein and can be used in the processes for producing the ***thiol*** ester compositions.

DETD ***Thiol*** Esters from Unsaturated Esters

DETD As an embodiment of the present invention, the ***thiol*** esters described herein can be produced by a process comprising contacting hydrogen sulfide and an unsaturated ester composition and

reacting
 the hydrogen sulfide and the unsaturated ester composition to form
 the ***thiol*** ester composition. In one embodiment, the
 unsaturated ester composition includes unsaturated esters having an average
 of at least 1.5 ester groups and an average of at least 1.5 carbon-
 carbon double bonds per unsaturated ester molecule. In this embodiment,
 the ***thiol*** ester composition includes ***thiol*** ester
 molecules having a molar ratio of cyclic sulfides to ***thiol*** groups
 of less than 1.5.

DETD The processes for producing the ***thiol*** ester
 composition can be applied to any of the unsaturated esters described herein and
 used to produce any of the ***thiol*** esters described herein. The
 process for producing the ***thiol*** ester composition can also
 include any additional process steps or process conditions described herein.

DETD The hydrogen sulfide to molar equivalents of unsaturated ester
 carbon-carbon double bonds molar ratio utilized in the process to
 produce the ***thiol*** ester composition can be any molar
 ratio that produces the desired ***thiol*** ester. The molar
 equivalents of unsaturated ester carbon-carbon double bonds is calculated by
 the equation:
$$\# \text{EQU1} \#$$
 In this equation, UES GMW is the average
 gram molecular weight of the unsaturated ester, UES Mass is the mass
 of the feedstock unsaturated ester, and UES C.dbd.C is the average
 number of double bonds per unsaturated ester molecule. In some embodiments,
 the ***thiol*** ester molecules have a molar ratio of the
 hydrogen sulfide to the unsaturated ester carbon-carbon double bonds of greater
 than 2.

In other embodiments, the hydrogen sulfide to unsaturated ester
 carbon-carbon double bonds molar ratio is greater than 5;
 alternatively, greater than 10; alternatively, greater than 15; or
 alternatively, greater than 20. In other embodiments, the hydrogen sulfide to
 unsaturated ester carbon-carbon double bonds molar ratio can be
 from 2 to 500; alternatively, from 5 to 200; alternatively, from 10 to
 100; or alternatively, from 100 to 200.

DETD When a continuous reactor is used, a feed unsaturated ester
 weight hourly space velocity ranging from 0.1 to 5 can be used to
 produce the

desired ***thiol*** ester. Alternatively, the feed unsaturated ester weight hourly space velocity ranges between 0.1 to 5; alternatively, from 0.1 to 2. Alternatively, the feed unsaturated ester weight hourly space velocity is 0.1; alternatively, the feed unsaturated ester weight hourly space velocity is 0.25; or alternatively, the feed unsaturated ester weight hourly space velocity is 2.

DETD The time required for the reaction of the unsaturated ester and hydrogen sulfide can be any time required to form the described ***thiol*** ester. Generally, the time required for the reaction of the unsaturated ester and hydrogen sulfide is at least 5 minutes.

In some embodiments, the time required for the reaction of the unsaturated ester and hydrogen sulfide ranges from 5 minutes to 72 hours; alternatively, from 10 minutes to 48 hours; or alternatively, from 15 minutes to 36 hours.

DETD In embodiments, the process to produce the ***thiol*** ester further comprises a step to remove excess or residual hydrogen sulfide after reacting the hydrogen sulfide and the unsaturated ester composition. In some embodiments, the ***thiol*** ester is vacuum stripped. In some embodiments, the ***thiol*** ester is vacuum stripped at a temperature ranging between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the ***thiol*** ester is sparged with an inert gas to remove hydrogen sulfide. In some embodiments, the ***thiol*** ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C.

C. In some aspects, the inert gas is nitrogen. Generally, the stripped or sparged ***thiol*** ester comprises less than 0.1 weight percent hydrogen sulfide. In other embodiments, the stripped or sparged ***thiol*** ester comprises less than 0.05 weight percent sulfur; alternatively, less than 0.025 weight percent hydrogen sulfide; or alternatively, less than 0.01 weight percent hydrogen sulfide.

DETD The reaction between the unsaturated ester and hydrogen sulfide can be performed at any temperature capable of forming the ***thiol*** ester. In some embodiments, the unsaturated ester and hydrogen sulfide can be reacted at a temperature greater than -20.degree. C. In other

embodiments, the unsaturated ester and hydrogen sulfide can be reacted at a temperature greater than 0.degree. C.; alternatively, greater than 20.degree. C.; alternatively, greater than 50.degree. C.; alternatively, greater than 80.degree. C.; or alternatively, greater than 100.degree. C. In yet other embodiments, the unsaturated ester and hydrogen sulfide can be reacted at a temperature from -20.degree. C. to 200.degree. C.; alternatively, from 120.degree. C. to 240.degree. C.; alternatively, from 170.degree. C. to 210.degree. C.; alternatively, from 185.degree. C. to 195.degree. C.; alternatively, from 20.degree. C. to 200.degree. C.; alternatively, from 20.degree. C. to 170.degree. C.; or alternatively, from 80.degree. C. to 140.degree. C.

DETD ***Thiol*** esters having a low cyclic sulfide content can be produced using the disclosed process. In an aspect, the process for producing the ***thiol*** ester forms or produces a ***thiol*** ester having a molar ratio of cyclic sulfide to ***thiol*** groups of less than 1.5. Additional cyclic sulfide to ***thiol*** groups molar ratios are disclosed herein.

DETD In addition to lower cyclic sulfide content, ***thiol*** esters having a low carbon-carbon double bond to ***thiol*** group molar ratio can also be produced using the disclosed process. In an aspect, the process described herein produces the ***thiol*** ester having a carbon-carbon double bond to ***thiol*** group molar ratio of less than 1.5. Additional carbon-carbon double bond to ***thiol*** group molar ratios are disclosed herein.

DETD In some aspects, the process described herein produces the ***thiol*** ester molecules having an average of greater than 5 weight percent ***thiol*** sulfur. Additional ***thiol*** sulfur contents are disclosed herein. In other aspects, the process for producing a ***thiol*** ester forms a ***thiol*** ester having greater than 40 percent of the ***thiol*** ester total side chains include sulfur. Other percentages of the ***thiol*** ester total side chains that include sulfur are disclosed herein.

DETD In some embodiments, the process for producing a ***thiol*** ester composition includes contacting an unsaturated ester and hydrogen sulfide and reacting the unsaturated ester and the hydrogen

sulfide to form a ***thiol*** ester. The ***thiol*** ester comprises ***thiol*** ester molecules that have a ratio of cyclic sulfide to ***thiol*** groups of less than 1.5.

DETD ***Thiol*** Ester from a Polyol and a ***Thiol***

Containing Carboxylic Acid Derivative

DETD As another embodiment of the present invention, another process to produce the ***thiol*** ester composition is advantageously provided. In this embodiment, the process includes the steps of contacting a composition comprising a polyol with a composition comprising a ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative and reacting the polyol and ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative to produce the ***thiol*** ester composition. This process can be applied to any polyol, ***thiol*** containing carboxylic acid, or ***thiol*** containing carboxylic acid derivative described herein. The process for producing the ***thiol*** ester composition can also include any additional process steps or process conditions described herein. Additionally, the process for producing the ***thiol*** ester composition can form any ***thiol*** ester described herein.

DETD In some embodiments, the ***thiol*** ester composition includes ***thiol*** ester molecules that have an average of at least 1.5 ester groups and an average of at least 1.5 ***thiol*** groups per ***thiol*** ester molecule.

DETD The polyol used to produce the ***thiol*** ester by contacting a polyol and a ***thiol*** carboxylic acid and/or ***thiol*** carboxylic acid equivalent (for example a ***thiol*** carboxylic acid methyl ester) can be any polyol or mixture of polyols that can produce the described ***thiol*** containing ester.

DETD In one aspect, the polyol used to produce the ***thiol*** ester can comprise from 2 to 20 carbon atoms. In other embodiments, the polyol comprises from 2 to 10 carbon atoms; alternatively from 2 to 7 carbon atoms; alternatively from 2 to 5 carbon atoms. In further embodiments, the polyol may be a mixture of polyols having an average of 2 to 20 carbon atoms; alternatively, an average of from 2 to 10 carbon atoms; alternatively, an average of 2 to 7 carbon atoms; alternatively an average of 2 to 5 carbon atoms.

DETD In another aspect, the polyol used to produce the ***thiol***

ester can have any number of hydroxy groups needed to produce the ***thiol*** ester as described herein. In some embodiments, the polyol has 2 hydroxy groups; alternatively 3 hydroxy groups; alternatively, 4 hydroxy groups; alternatively, 5 hydroxy groups; or alternatively, 6 hydroxy groups. In other embodiments, the polyol comprises at least 2 hydroxy groups; alternatively at least 3 hydroxy groups; alternatively, at least 4 hydroxy groups; or alternatively, at least 5 hydroxy groups; at least 6 hydroxy groups. In yet other embodiments, the polyol comprises from 2 to 8 hydroxy groups; alternatively, from 2 to 4 hydroxy groups; or alternatively from 4 to 8 hydroxy groups.

DETD In further aspects, the polyol used to produce the ***thiol*** ester is a mixture of polyols. In an embodiment, the mixture of polyols has an average of at least 1.5 hydroxy groups per polyol molecule. In other embodiments, the mixture of polyols has an average of at least 2 hydroxy groups per polyol molecule; alternatively, an average of at least 2.5 hydroxy groups per polyol molecule; alternatively, an average of at least 3.0 hydroxy groups per polyol molecule; or alternatively, an average of at least 4 hydroxy groups per polyol molecule. In yet another embodiment, the mixture of polyols has an average of 1.5 to 8 hydroxy groups per polyol molecule; alternatively, an average of 2 to 6 hydroxy groups per polyol molecule; alternatively, an average of 2.5 to 5 hydroxy groups per polyol molecule; alternatively, an average of 3 to 4 hydroxy groups per polyol molecule; alternatively, an average of 2.5 to 3.5 hydroxy groups per polyol molecule; or alternatively, an average of 2.5 to 4.5 hydroxy groups per polyol molecule.

DETD In yet another aspect, the polyol or mixture of polyols used to produce the ***thiol*** ester has a molecular weight or average molecular weight less than 500. In other embodiments, the polyol or mixture of polyols have a molecular weight or average molecular weight less than 300; alternatively less than 200; alternatively, less than 150; or alternatively, less than 100.

DETD The ***thiol*** carboxylic acid and/or ***thiol*** carboxylic acid equivalent used to produce the ***thiol*** ester by contacting

a polyol and a ***thiol*** carboxylic acid and/or
 thiol carboxylic acid equivalent can be any ***thiol*** carboxylic acid mixture comprising ***thiol*** carboxylic acids, ***thiol*** carboxylic acid equivalent or mixture comprising ***thiol*** carboxylic acid equivalents that can produce the described containing ester. When talking about the characteristics ***thiol*** carboxylic acid equivalent or ***thiol*** carboxylic acid equivalents, properties such as number of carbon atoms, average number of carbon atom, molecular weight or average molecular weight, number of ***thiol*** group, and average number of ***thiol*** groups, one will understand the these properties will apply to the portion of the ***thiol*** carboxylic acid equivalent which adds to the polyol to form the ***thiol*** ester.
 DETD In an aspect, the ***thiol*** carboxylic acid and/or ***thiol*** carboxylic acid equivalent used to produce the ***thiol*** ester comprises from 2 to 28 carbon atoms. In an embodiment, the ***thiol*** carboxylic acid and/or ***thiol*** carboxylic acid equivalent comprises from 4 to 26 carbon atoms; alternatively, from 8 to 24 carbon atoms; alternatively, from 12 to 24 carbon atoms; or alternatively, from 14 to 20 carbon atoms. In other embodiments, a mixture comprising ***thiol*** carboxylic acid and/or mixture comprising carboxylic acid equivalents has an average of 2 to 28 carbon atoms per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 4 to 26 carbon atoms per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 8 to 24 carbon atoms per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 12 to 24 carbon atoms per carboxylic acid and/or carboxylic acid equivalent; or alternatively, from 14 to 20 carbon atoms per carboxylic acid and/or carboxylic acid equivalent.
 DETD In another aspect, the ***thiol*** carboxylic acid and/or ***thiol*** carboxylic acid equivalent used to produce the ester has at least 1 ***thiol*** group; alternatively 2 ***thiol*** groups. In some embodiments, a mixture comprising ***thiol*** carboxylic acid and/or mixture comprising ***thiol*** carboxylic acid equivalents has an average of from 0.5 to 3 groups per carboxylic acid and/or carboxylic acid

equivalent; alternatively, an average of from 1 to 2
thiol
groups per carboxylic acid and/or carboxylic acid equivalent.
DETD In another aspect, the ***thiol*** carboxylic acid and/or
thiol carboxylic acid equivalent used to produce the
thiol ester has a molecular weight greater than 100;
alternatively greater than 180; alternatively greater than 240;
or
alternatively greater than 260. In other embodiments, the
thiol
carboxylic acid and/or ***thiol*** carboxylic acid equivalent
has a
molecular weight from 100 to 500; alternatively, from 120 to 420;
alternatively, from 180 to 420; alternatively, from 240 to 420; a
mixture or alternatively, from 260 to 360. In some embodiments, a
mixture comprising ***thiol*** carboxylic acid and/or mixture
comprising ***thiol*** carboxylic acid equivalents has an
average
molecular weight greater than 100 per carboxylic acid and/or
carboxylic
acid equivalent; alternatively greater than 180 per carboxylic
acid
and/or carboxylic acid equivalent; alternatively greater than 240
per
carboxylic acid and/or carboxylic acid equivalent; or
alternatively
greater than 260 per carboxylic acid and/or carboxylic acid
equivalent.
In yet other embodiments, the mixture comprising of ***thiol***
carboxylic acid and/or mixture comprising ***thiol***
carboxylic
acid equivalents has an average molecular weight from 100 to 500
per
carboxylic acid and/or carboxylic acid equivalent; alternatively,
from
120 to 420 per carboxylic acid and/or carboxylic acid equivalent;
alternatively, from 180 to 420 per carboxylic acid and/or
carboxylic
acid equivalent; alternatively, from 240 to 420 per carboxylic
acid
and/or carboxylic acid equivalent; a mixture or alternatively,
from 260
to 360 per carboxylic acid and/or carboxylic acid equivalent.
DETD In some aspects, the reaction between the polyol and the
thiol
containing carboxylic acid and/or ***thiol*** containing
carboxylic
acid derivative occurs in the presence of a solvent. In other
aspects
the reaction between the polyol and the ***thiol***
containing
carboxylic acid and/or ***thiol*** containing carboxylic acid
derivative occurs in the substantial absence of a solvent. In
aspects
wherein the reaction between the polyol and the ***thiol***
containing carboxylic acid and/or ***thiol*** containing
carboxylic
acid derivative occurs in the presence of a solvent, the solvent
is
selected from the group consisting of an aliphatic hydrocarbon,

an ether, an aromatic compound, or any combination thereof.

Generally, the solvent, regardless of its chemical class, can include from 1 to 20 carbon atoms; or alternatively, from 3 to 10 carbon atoms. When the solvent includes the aliphatic hydrocarbon, the aliphatic hydrocarbon is butane, isobutane, pentane, hexane, heptane, octane, or any mixture thereof. When the solvent includes the aromatic compound, the aromatic compound is benzene, toluene, xylene, ethylbenzene, or any mixture thereof. When the solvent includes the ether, the ether is diethyl ether, dipropyl ether, tetrahydrofuran, and any mixture thereof.

DETD When a solvent is used for the reaction between the polyol and the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative, the quantity of solvent can be any amount that facilitates the reaction. In some embodiments, the mass of the solvent is less than 30 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative. In other embodiments, the mass of the solvent is less than 20 times the mass of the unsaturated ester oil; alternatively, less than 15 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative; alternatively, less than 10 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative; or alternatively, less than 5 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative. In other embodiments, the mass of the solvent is from 2 times to 20 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative; alternatively, from 3 times to 15 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative; or alternatively, from 5 times to 10 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative.

DETD The equivalent of ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative carboxylic acid

groups to equivalents of polyol hydroxy groups molar ratio (hereinafter "carboxylic acid group to polyol hydroxy group molar ratio") utilized in the process to produce the ***thiol*** ester composition can be any carboxylic acid group to polyol hydroxy group molar ratio that produces the desired ***thiol*** ester composition. In some embodiments, the carboxylic acid group to polyol hydroxy group molar ratio is greater than 0.4. In other embodiments, the carboxylic acid group to polyol hydroxy group molar ratio is greater than 0.6; alternatively, greater than 0.8; alternatively, greater than 1; or alternatively, greater than 1.1. In other embodiments, the carboxylic acid group to polyol hydroxy group molar ratio can range from 0.4 to 1.3; alternatively, from 0.6 to 1.2, or alternatively, from 0.8 to 1.1.

DETD In some aspects, the reaction between the polyol and the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative is catalyzed. In some embodiments, the catalyst is a mineral acid, such as sulfuric or phosphoric acid. In other embodiments, the catalyst is an organic acid. In embodiments, for example, the organic acid is methane sulfonic acid or toluene sulfonic acid.

Other suitable types of catalyst will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD The reaction of the polyol and the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative can occur in a batch reactor or a continuous reactor, as described herein. The reaction between the polyol and the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative can be performed at any temperature capable of forming the ***thiol*** ester. In some embodiments, the polyol and the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative can be reacted at a temperature greater than 20.degree. C. In other embodiments, the polyol and the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative can be reacted at a temperature greater than 50.degree. C.; alternatively, greater than 75.degree. C.;

or alternatively, greater than 100.degree. C. In yet other
embodiments,
the polyol and the ***thiol*** containing carboxylic acid
and/or
thiol containing carboxylic acid derivative can be
reacted at a
temperature from 20.degree. C. to 250.degree. C.; alternatively,
from
50.degree. C. to 200.degree. C.; alternatively, from 75.degree.
C. to
175.degree. C.; or alternatively, from 100.degree. C. to
150.degree. C.
DETD The time required for the reaction of the polyol and the
thiol
containing carboxylic acid and/or ***thiol*** containing
carboxylic
acid derivative can be any time required to form the described
thiol ester oil. Generally, the reaction time of the
polyol and
the ***thiol*** containing carboxylic acid and/or
thiol
containing carboxylic acid derivative is at least 5 minutes. In
some
embodiments, the reaction time is at least 30 minutes;
alternatively, at
least 1 hour; or alternatively, at least 2 hours. In yet other
embodiments, the reaction time ranges from 5 minutes to 72 hours;
alternatively, from 30 minutes to 48 hours; alternatively, from 1
hour
minutes to 36 hours; or alternatively, from 2 hours and 24 hours.
DETD When a continuous reactor is used, a feed polyol weight
unsaturated
ester weight hourly space velocity ranging from 0.1 to 5 can be
used to
produce the desired ***thiol*** ester. Alternatively, the
feed
polyol weight hourly space velocity ranges between 0.1 to 5;
alternatively, from 0.1 to 2. Alternatively, the feed polyol
ester
weight hourly space velocity is 0.1; alternatively, the feed
polyol
weight hourly space velocity is 0.25; or alternatively, the feed
polyol
weight hourly space velocity is 2.
DETD The reaction between the polyol and the ***thiol***
containing
carboxylic acid and/or ***thiol*** containing carboxylic acid
derivative can be performed at any reaction pressure that
maintains the
polyol and the ***thiol*** containing carboxylic acid and/or
thiol
containing carboxylic acid derivative in a liquid
state.
In some embodiments, the reaction between the polyol and the
thiol containing carboxylic acid and/or ***thiol***
containing carboxylic acid derivative is performed at a pressure
ranging
from 0 psia to 2000 psia. In other embodiments, the reaction
pressure
ranges from 0 psia to 1000 psia; alternatively, from 0 psia and
500

psia; or alternatively, 0 psia to 300 psia.

DETD In some embodiments, the process to produce the ***thiol*** ester by reacting a polyol and the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative can further include a step to remove excess or residual polyol, ***thiol*** containing carboxylic acid, and/or ***thiol*** containing carboxylic acid derivative once the polyol has reacted with the ***thiol*** containing carboxylic acid or ***thiol*** containing carboxylic acid derivative. In some embodiments, the ***thiol*** ester is vacuum stripped. In some embodiments, the ***thiol*** ester is vacuum stripped at a temperature ranging between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the ***thiol*** ester is sparged with an inert gas to remove excess polyol, ***thiol*** containing carboxylic acid, and/or ***thiol*** containing carboxylic acid derivative. In some embodiments, the ***thiol*** ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In some aspects, the inert gas is nitrogen. Generally, the stripped or sparged ***thiol*** ester comprises less than 5 excess polyol, ***thiol*** containing carboxylic acid, or ***thiol*** containing carboxylic acid derivative. In other embodiments, the stripped or sparged ***thiol*** ester comprises less than 2 weight percent excess polyol, ***thiol*** containing carboxylic acid, and/or ***thiol*** containing carboxylic acid derivative; alternatively, less than 1 weight percent excess polyol, ***thiol*** containing carboxylic acid, and/or ***thiol*** containing carboxylic acid derivative; or alternatively, less than 0.5 weight percent excess polyol, ***thiol*** containing carboxylic acid, and/or ***thiol*** containing carboxylic acid derivative.

DETD Process for Making Hydroxy ***Thiol*** Ester Composition

DETD The present invention advantageously provides processes for producing a hydroxy ***thiol*** ester as embodiments of the present invention.

As an embodiment, the present invention includes a process to produce the hydroxy ***thiol*** ester. The process comprises the

steps of contacting hydrogen sulfide and an epoxidized unsaturated ester composition and reacting the hydrogen sulfide and the epoxidized unsaturated ester to form the hydroxy ***thiol*** ester. As another embodiment of the present invention, another process to produce the hydroxy ***thiol*** ester is provided. In this embodiment, the process comprises the steps of contacting a composition comprising a polyol with a composition comprising an hydroxy ***thiol*** containing carboxylic acid or an hydroxy ***thiol*** containing carboxylic acid derivative and reacting the polyol and the hydroxy ***thiol*** containing carboxylic acid or the hydroxy ***thiol*** containing carboxylic acid derivative to form the hydroxy ester.

DETD Hydroxy ***Thiol*** Ester from Hydrogen Sulfide and an Epoxidized Unsaturated Ester Composition

DETD As an embodiment of the present invention, the hydroxy ***thiol*** ester composition is produced by a process comprising the steps of contacting hydrogen sulfide and an epoxidized unsaturated ester composition and reacting the hydrogen sulfide and the epoxidized unsaturated ester to produce the hydroxy ***thiol*** ester composition.

DETD In some embodiments, the epoxidized unsaturated ester composition includes epoxidized unsaturated esters that have an average of at least 1 ester groups and an average of at least 1 ***epoxide*** groups per epoxidized unsaturated ester molecule.

DETD The process for producing or preparing the hydroxy ***thiol*** ester composition can be applied to any of the epoxidized unsaturated esters described herein and used to produce any hydroxy ***thiol*** ester described herein. The process for producing the hydroxy ***thiol*** ester can also include any additional process steps or process conditions as described herein. Additionally, the process for producing the hydroxy ***thiol*** ester can form any hydroxy ***thiol*** ester described herein.

DETD In some aspects, the hydroxy ***thiol*** ester is produced by contacting hydrogen sulfide with the epoxidized natural source oil under the reaction conditions to form the hydroxy ***thiol*** ester in the presence of an optional catalyst. In some embodiments, the catalyst can be a heterogeneous catalyst or a homogeneous catalyst. Examples of

suitable catalysts are described herein. Additional types of suitable catalysts will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD The hydrogen sulfide to molar equivalents of ***epoxide*** groups in the epoxidized unsaturated ester (hereinafter "hydrogen sulfide to ***epoxide*** group molar ratio") utilized in the process to produce the hydroxy ***thiol*** ester can be any hydrogen sulfide to ***epoxide*** group molar ratio that produces the desired hydroxy ***thiol*** ester. The molar equivalents of epoxidized unsaturated ester epoxidized groups can be calculated by the equation:

#EQU2## In this equation, EUES GMW is the average gram molecular weight of the epoxidized unsaturated ester, EUES Mass is the mass of the epoxidized unsaturated ester, and EUES ***Epoxide*** is the average number of ***epoxide*** groups per epoxidized unsaturated ester molecule. In some embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio is greater than 0.2. In other embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio is greater than 0.5; alternatively, greater than 1; or alternatively, greater than 2. In other embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio ranges from 0.2 to 5; alternatively, from 0.5 to 4; or alternatively, from 0.75 to 3. In some embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio is greater than 2. In other embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio is greater than 5; alternatively, greater than 10; alternatively, greater than 15; or alternatively, greater than 20. In other embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio can be from 0.2 to 500; alternatively, from 0.5 to 400; alternatively, from 1 to 300; alternatively, from 2 to 250; alternatively, 5 to 200; or alternatively, from 10 to 100.

DETD The time required for the reaction of the epoxidized unsaturated ester and hydrogen sulfide can be any time required to form the described hydroxy ***thiol*** ester. Generally, the time required for the reaction of the epoxidized unsaturated ester and hydrogen sulfide is at

least 15 minutes. In some embodiments, the time required for the reaction of the unsaturated ester and hydrogen sulfide ranges from 15 minutes to 72 hours; alternatively, from 30 minutes to 48 hours; alternatively, from 45 minutes to 36 hours.

DETD In some embodiments, the hydroxy ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules that have an average of greater than 2.5 weight percent ***thiol*** sulfur. In some embodiments, the hydroxy ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules that have an average of greater than 5 weight percent ***thiol*** sulfur. Alternatively, in some embodiments, the hydroxy ***thiol*** ester molecules have an average ranging from 8 to 10 weight percent ***thiol*** sulfur.

DETD In other aspects, the process producing the hydroxy ***thiol*** ester composition includes producing hydroxy ***thiol*** ester molecules having an average of greater than 40 percent of the sulfide-containing ester total side chains comprise a sulfide group. Additional embodiments wherein the hydroxy ***thiol*** ester comprises a percentage of sulfide-containing ester total side chains are described herein.

DETD In embodiments, the process to produce the hydroxy ***thiol*** ester further comprises a step to remove residual hydrogen sulfide after reacting the hydrogen sulfide and the epoxidized unsaturated ester composition. In some embodiments, the hydroxy ***thiol*** ester is vacuum stripped. In some embodiments, the hydroxy ***thiol*** ester is vacuum stripped at a temperature ranging between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the hydroxy ***thiol*** ester is sparged with an inert gas to remove hydrogen sulfide. In some embodiments, the hydroxy ***thiol*** ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In some aspects, the inert gas is nitrogen. Generally, the stripped or sparged hydroxy ***thiol*** ester comprises less than 0.1 weight percent hydrogen sulfide. In other embodiments, the stripped or sparged hydroxy ***thiol*** ester comprises less than 0.05 weight percent hydrogen sulfide; alternatively,

less than 0.025 weight percent hydrogen sulfide; or alternatively, less than 0.01 weight percent hydrogen sulfide.

DETD The reaction between the hydrogen sulfide and the epoxidized unsaturated ester can be performed at any temperature capable of forming the hydroxy ***thiol*** ester. In some embodiments, the epoxidized unsaturated ester and hydrogen sulfide can be reacted at a reaction temperature greater than -20.degree. C. In other embodiments, the reaction temperature is greater than 0.degree. C.; alternatively, greater than 20.degree. C.; alternatively, greater than 50.degree. C.; or alternatively, greater than 80.degree. C. In yet other embodiments, the reaction temperature ranges from -20.degree. C. to 200.degree. C.; alternatively, from 20.degree. C. to 170.degree. C.; or alternatively, from 80.degree. C. to 140.degree. C.

DETD In another aspect, the process to produce a hydroxy ***thiol*** ester produces a hydroxy ***thiol*** ester having an ***epoxide*** group to ***thiol*** group molar ratio less than 3.3. In another aspect, the process to produce a hydroxy ***thiol*** ester produces a hydroxy ***thiol*** ester having an ***epoxide*** group to ***thiol*** group molar ratio less than 2. Other hydroxy ***thiol*** ester ***epoxide*** group to ***thiol*** group molar ratios are described herein. Alternatively, the hydroxy ***thiol*** ester ***epoxide*** group to ***thiol*** group molar ratio can be less than 1.5; alternatively, less than 1.0; alternatively, less than 0.5; alternatively, less than 0.25; or alternatively, less than 0.1.

In other embodiments, the hydroxy ***thiol*** ester can be substantially free of ***epoxide*** groups.

DETD In another aspect, the process to produce hydroxy ***thiol*** ester produces a hydroxy ***thiol*** ester wherein at least 20 percent of the side chains comprise an .alpha.-hydroxy ***thiol*** group. Other hydroxy ***thiol*** ester embodiments wherein the hydroxy ***thiol*** ester contains a percentage of side chains comprising .alpha.-hydroxy ***thiol*** groups are described herein.

DETD Hydroxy ***Thiol*** Ester from a Polyol and a Hydroxy ***Thiol*** Containing Carboxylic Acid Derivative

DETD As another embodiment of the present invention, another process

to prepare the hydroxy ***thiol*** ester is advantageously provided. In this embodiment, the process includes the steps of contacting a composition comprising a polyol with a composition comprising a hydroxy ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative and reacting the polyol and hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid to form a hydroxy ***thiol*** ester composition. This process can be applied to any polyol, any hydroxy ***thiol*** containing carboxylic acid, or any ***thiol*** containing carboxylic acid derivative described herein. The process for producing the hydroxy ***thiol*** ester composition can also include any additional process steps or process conditions described herein. Additionally, the process for producing the hydroxy ***thiol*** ester composition can form any ***thiol*** ester described herein.

DETD In some embodiments, the hydroxy ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules that have an average of at least 1 ester groups per hydroxy ***thiol*** ester molecule and an average of at least 1 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule.

DETD The polyol used to produce the hydroxy ***thiol*** ester by contacting a polyol and a hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent (for example a hydroxy ***thiol*** carboxylic acid methyl ester) can be any polyol or mixture of polyols that can produce the described ***thiol*** containing ester.

DETD In one aspect, the polyol used to produce the hydroxy ***thiol*** ester can comprise from 2 to 20 carbon atoms. In other embodiments, the polyol comprises from 2 to 10 carbon atoms; alternatively from 2 to 7 carbon atoms; alternatively from 2 to 5 carbon atoms. In further embodiments, the polyol may be a mixture of polyols having an average of 2 to 20 carbon atoms; alternatively, an average of from 2 to 10 carbon atoms; alternatively, an average of 2 to 7 carbon atoms; alternatively an average of 2 to 5 carbon atoms.

DETD In another aspect, the polyol used to produce the hydroxy ***thiol*** ester can have any number of hydroxy groups needed to produce the hydroxy ***thiol*** ester as described herein. In some embodiments,

the polyol has 2 hydroxy groups; alternatively 3 hydroxy groups; alternatively, 4 hydroxy groups; alternatively, 5 hydroxy groups;

or alternatively, 6 hydroxy groups. In other embodiments, the polyol comprises at least 2 hydroxy groups; alternatively at least 3 hydroxy groups; alternatively, at least 4 hydroxy groups; or alternatively, at least 5 hydroxy groups; at least 6 hydroxy groups. In yet other embodiments, the polyol comprises from 2 to 8 hydroxy groups; alternatively, from 2 to 4 hydroxy groups; or alternatively from 4 to 8 hydroxy groups.

DETD In further aspects, the polyol used to produce the hydroxy ***thiol*** ester is a mixture of polyols. In an embodiment, the mixture of polyols has an average of at least 1.5 hydroxy groups per polyol molecule. In other embodiments, the mixture of polyols has an average of at least 2 hydroxy groups per polyol molecule; alternatively, an average of at least 2.5 hydroxy groups per polyol molecule; alternatively, an average of at least 3.0 hydroxy groups per polyol molecule; or alternatively, an average of at least 4 hydroxy groups per polyol molecule. In yet another embodiment, the mixture of polyols has an average of 1.5 to 8 hydroxy groups per polyol molecule; alternatively, an average of 2 to 6 hydroxy groups per polyol molecule; alternatively, an average of 2.5 to 5 hydroxy groups per polyol molecule; alternatively, an average of 3 to 4 hydroxy groups per polyol molecule; alternatively, an average of 2.5 to 3.5 hydroxy groups per polyol molecule; or alternatively, an average of 2.5 to 4.5 hydroxy groups per polyol molecule.

DETD In yet another aspect, the polyol or mixture of polyols used to produce the hydroxy ***thiol*** ester has a molecular weight or average molecular weight less than 500. In other embodiments, the polyol or mixture of polyols have a molecular weight or average molecular weight less than 300; alternatively less than 200; alternatively, less than 150; or alternatively, less than 100.

DETD The hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent used to produce the hydroxy ***thiol*** ester by contacting a polyol and a hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent can be any hydroxy ***thiol*** carboxylic acid mixture comprising hydroxy ***thiol*** carboxylic acids, hydroxy

hydroxy ***thiol*** carboxylic acid equivalent or mixture comprising described hydroxy ***thiol*** carboxylic acid equivalents that can produce the characteristics hydroxy ***thiol*** carboxylic acid equivalent or hydroxy ***thiol*** carboxylic acid equivalents, properties such as number of carbon atoms, average number of carbon atom, molecular weight or average molecular weight, number of ***thiol*** group, and average number of ***thiol*** groups, one will understand the these properties will apply to the portion of the ***thiol*** carboxylic acid equivalent which adds to the polyol to form the ***thiol*** ester.

DETD In an aspect, the hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent used to produce the ***thiol*** ester comprises from 2 to 28 carbon atoms. In an embodiment, the hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalents comprises from 4 to 26 carbon atoms; alternatively, from 8 to 24 carbon atoms; alternatively, from 12 to 24 carbon atoms; or alternatively, from 14 to 20 carbon atoms.

In other embodiments, a mixture comprising hydroxy ***thiol*** carboxylic acids and/or mixture comprising hydroxy ***thiol*** carboxylic acid equivalents has an average of 2 to 28 carbon atoms per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 4 to 26 carbon per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 8 to 24 carbon atoms per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 12 to 24 carbon per carboxylic acid and/or carboxylic acid equivalent; or alternatively, from 14 to 20 carbon atoms per carboxylic acid and/or carboxylic acid equivalent.

DETD In another aspect, the hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent used to produce the ***thiol*** ester has at least 1 ***thiol*** group; alternatively 2 ***thiol*** groups. In some embodiments, a mixture comprising hydroxy ***thiol*** carboxylic acids and/or mixture comprising hydroxy ***thiol*** carboxylic acid equivalents has an average of

from 0.5 to 3 ***thiol*** groups per carboxylic acid and/or carboxylic acid equivalent; alternatively, an average of from 1 to 2 ***thiol*** groups per carboxylic acid and/or carboxylic acid equivalent.

DETD In another aspect, the hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent used to produce the ***thiol*** ester has at least 1 hydroxy group; alternatively, at least 2 hydroxy groups. In some embodiments, a mixture comprising hydroxy ***thiol*** carboxylic acids and/or mixture comprising hydroxy ***thiol*** carboxylic acid equivalents has an average of from 0.5 to 3 hydroxy groups per carboxylic acid and/or carboxylic acid equivalent; alternatively, an average of from 1 to 2 hydroxy groups per carboxylic acid and/or carboxylic acid equivalent.

DETD In another aspect, the hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent used to produce the hydroxy ***thiol*** ester has a molecular weight greater than 100; alternatively greater than 180; alternatively greater than 240; or alternatively greater than 260. In other embodiments, the hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent has a molecular weight from 100 to 500; alternatively, from 120 to 420; alternatively, from 180 to 420; alternatively, from 240 to 420; or alternatively, from 260 to 360. In some embodiments, a mixture comprising hydroxy ***thiol*** carboxylic acids and/or mixture comprising hydroxy ***thiol*** carboxylic acid equivalents has an average molecular weight greater than 100 per carboxylic acid and/or carboxylic acid equivalent; alternatively greater than 180 per carboxylic acid and/or carboxylic acid equivalent; alternatively greater than 240 per carboxylic acid and/or carboxylic acid equivalent; or alternatively greater than 260 per carboxylic acid and/or carboxylic acid equivalent. In yet other embodiments, the mixture comprising hydroxy ***thiol*** carboxylic acid and/or mixture comprising hydroxy ***thiol*** carboxylic acid equivalents has an average molecular weight from 100 to 500 per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 120 to 420 per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 180 to 420 per carboxylic acid and/or carboxylic acid equivalent;

alternatively, from 240 to 420 per carboxylic acid and/or carboxylic acid equivalent; a mixture or alternatively, from 260 to 360 per carboxylic acid and/or carboxylic acid equivalent.

DETD In some aspects, the reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative occurs in the presence of a solvent. In other aspects, the reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative occurs in the substantial absence of a solvent. In aspects wherein the reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative occurs in the presence of a solvent, the solvent is selected from the group consisting of an aliphatic hydrocarbon, an ether, an aromatic compound, or any combination thereof. Generally, the solvent, regardless of its chemical class, includes from 1 to 20 carbon atoms; alternatively, from 3 to 10 carbon atoms. When the solvent includes the aliphatic hydrocarbon, the aliphatic hydrocarbon is butane, isobutane, pentane, hexane, heptane, octane, or any mixture thereof. When the solvent includes the aromatic compound, the aromatic compound is benzene, toluene, xylene, ethylbenzene, or any mixture thereof.

When the solvent includes the ether, the ether is diethyl ether, dipropyl ether, tetrahydrofuran, and any mixture thereof.

DETD When a solvent is used for the reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative, the quantity of solvent can be any amount that facilitates the reaction. In some embodiments, the mass of the solvent is less than 30 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative. In other embodiments, the mass of the solvent is less than 20 times the mass of the hydroxy ***thiol*** ester; alternatively, less than 15 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative; alternatively, less than 10 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative; or alternatively, less than 5 times

the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative. In other embodiments, the mass of the solvent is from 2 times to 20 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative; alternatively, from 3 times to 15 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative; or alternatively, from 5 times to 10 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative.

DETD The equivalents of hydroxy ***thiol*** containing carboxylic acid derivative and/or hydroxy ***thiol*** containing carboxylic acid derivative carboxylic acid groups to equivalents of polyol hydroxy groups molar ratio (hereinafter referred to as "carboxylic acid group to polyol hydroxy group molar ratio") utilized in the process to produce the hydroxy ***thiol*** ester can be any carboxylic acid group to polyol hydroxy group molar ratio that produces the desired hydroxy ***thiol*** ester. In some embodiments, the carboxylic acid group to polyol hydroxy group molar ratio is greater than 0.4. In other embodiments, the carboxylic acid group to polyol hydroxy group molar ratio is greater than 0.6; alternatively, greater than 0.8; alternatively, greater than 1; or alternatively, greater than 1.1. In other embodiments, the carboxylic acid group to polyol hydroxy group molar ratio ranges from 0.4 to 1.3; alternatively, from 0.6 to 1.2, or alternatively, from 0.8 to 1.1.

DETD In some aspects, the reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative is catalyzed. In some embodiments, the catalyst is a mineral acid, such as sulfuric or phosphoric acid. In other embodiments, the catalyst is an organic acid. In some embodiments, for example, the organic acid is methane sulfonic acid or toluene sulfonic acid. Other suitable types of catalyst will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD The reaction of the polyol and the hydroxy ***thiol***
containing
carboxylic acid and/or hydroxy ***thiol*** containing
carboxylic
acid derivative can occur in a batch reactor or a continuous
reactor, as
described herein. The reaction between the polyol and the hydroxy
thiol containing carboxylic acid and/or hydroxy
thiol
containing carboxylic acid derivative can be performed at any
temperature capable of forming the hydroxy ***thiol*** ester.

In
some embodiments, the polyol and the hydroxy ***thiol***
containing
carboxylic acid and/or hydroxy ***thiol*** containing
carboxylic
acid derivative can be reacted at a temperature greater than
20.degree.

C. In other embodiments, the polyol and the hydroxy ***thiol***
containing carboxylic acid and/or hydroxy ***thiol***
containing
carboxylic acid derivative can be reacted at a temperature
greater than
50.degree. C.; alternatively, greater than 75.degree. C.; or
alternatively, greater than 100.degree. C. In yet other
embodiments, the
polyol and the hydroxy ***thiol*** containing carboxylic acid
and/or
hydroxy ***thiol*** containing carboxylic acid derivative can
be
reacted at a temperature from 20.degree. C. to 250.degree. C.;
alternatively, from 50.degree. C. to 200.degree. C.;
alternatively, from
75.degree. C. to 175.degree. C.; or alternatively, from
100.degree. C.
to 150.degree..

DETD The time required for the reaction of the polyol and the hydroxy
thiol containing carboxylic acid and/or hydroxy
thiol
containing carboxylic acid derivative can be any time required to
form
the described hydroxy ***thiol*** ester composition.

Generally, the
reaction time is at least 5 minutes. In some embodiments, the
reaction
time is at least 30 minutes; alternatively, at least 1 hour; or
alternatively, at least 2 hours. In yet other embodiments, the
reaction
time ranges from 5 minutes to 72 hours; alternatively, from 30
minutes
to 48 hours; alternatively, from 1 hour minutes to 36 hours; or
alternatively, from 2 hours and 24 hours.

DETD The reaction between the polyol and the hydroxy ***thiol***
containing carboxylic acid and/or hydroxy ***thiol***
containing
carboxylic acid derivative can be performed at any reaction
pressure
that maintains the polyol and the hydroxy ***thiol***
containing
carboxylic acid and/or hydroxy ***thiol*** containing

carboxylic acid derivative in a liquid state. In some embodiments, the reaction pressure ranges from 0 psia to 2000 psia. In other embodiments, the reaction pressure ranges from 0 psia to 1000 psia; alternatively, from 0 psia and 500 psia; or alternatively, from 0 psia to 300 psia.

DETD In some embodiments, the process to produce the hydroxy ***thiol*** ester composition by reacting a polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative can further include a step to remove excess or residual polyol, hydroxy ***thiol*** containing carboxylic acid, and/or hydroxy ***thiol*** containing carboxylic acid derivative once the polyol has reacted with the hydroxy ***thiol*** containing carboxylic acid or hydroxy ***thiol*** containing carboxylic acid derivative. In some embodiments, the ***thiol*** ester is vacuum stripped. In some embodiments, the hydroxy ***thiol*** ester is vacuum stripped at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the hydroxy ***thiol*** ester is sparged with an inert gas to remove excess polyol, hydroxy ***thiol*** containing carboxylic acid, and/or hydroxy ***thiol*** containing carboxylic acid derivative. In some embodiments, the hydroxy ***thiol*** ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C., or alternatively, between 50.degree. C. and 200.degree. C. In some aspects, the inert gas is nitrogen. Generally, the stripped or sparged hydroxy ***thiol*** ester oil comprises less than 5 excess polyol, hydroxy ***thiol*** containing carboxylic acid, or hydroxy ***thiol*** containing carboxylic acid derivative. In other embodiments, the stripped or sparged hydroxy ***thiol*** ester oil comprises less than 2 weight percent excess polyol, hydroxy ***thiol*** containing carboxylic acid, and/or hydroxy ***thiol*** containing carboxylic acid derivative; less than 1 weight percent excess polyol, hydroxy ***thiol*** containing carboxylic acid, and/or

hydroxy ***thiol*** containing carboxylic acid derivative; or alternatively, less than 0.5 weight percent excess polyol,

hydroxy ***thiol*** containing carboxylic acid, and/or hydroxy ***thiol*** containing carboxylic acid derivative.

DETD A method of making a thioacrylate containing ester composition is advantageously provided as another embodiment of the present invention.

The process for producing the thioacrylate containing ester comprising contacting a ***thiol*** ester with an acrylate and converting at least one ***thiol*** group to a ***thiol*** acrylate group. The process can be applied to any of the ***thiol*** esters described herein and used to any thioacrylate ester described herein. The process for producing the thioacrylate ester can also include any additional process steps or process conditions described herein.

DETD The acrylate compound can be any acrylate compound capable of reacting with a ***thiol*** group to form the ***thiol*** acrylate group.

In some embodiments, the acrylate compound can be an acrylic halide. In other embodiments, the acrylate compound can be an acrylic acid. In yet other embodiments, the acrylate compound can be an acrylic anhydride.

DETD In some aspects, the conversion of the ***thiol*** group to a thioacrylate group occurs in the presence of a solvent. In other aspects the conversion of the ***thiol*** group to a thioacrylate group occurs in the substantial absence of a solvent. In aspects wherein the conversion of the ***thiol*** group to a thioacrylate group occurs in the presence of a solvent, the solvent may be an aliphatic hydrocarbon, an ether, and aromatic compound. Generally, the solvent, regardless of its chemical class, includes from 1 to 20 carbon atoms; or alternatively, from 3 to 10 carbon atoms. When the solvent includes the aliphatic hydrocarbon, the aliphatic hydrocarbon is butane, isobutane, pentane, hexane, heptane, octane, or any mixture thereof. When the solvent includes the aromatic compound, the aromatic compound is benzene, toluene, xylene, ethylbenzene, or any mixture thereof.

When the solvent includes the ether, the ether is diethyl ether, dipropyl ether, tetrahydrofuran, or any mixture thereof.

DETD When a solvent is used for the conversion of the ***thiol***
group to a thioacrylate group, the quantity of solvent can be any
amount that facilitates the reaction. In some embodiments, the mass of the
solvent is less than 30 times the mass of the ***thiol*** ester. In
other embodiments, the mass of the solvent is less than 20 times the
mass of the ***thiol*** ester; alternatively, less than 15 times the
mass of the ***thiol*** ester; alternatively, less than 10 times the
mass of the ***thiol*** ester; or alternatively, less than 5 times
the mass of the ***thiol*** ester. In other embodiments, the mass of
the solvent is from 2 times to 20 times the mass of the ***thiol***
ester; alternatively, from 3 times to 15 times the mass of the
thiol ester; alternatively, 4 times to 15 times the
mass of the ***thiol*** ester; or alternatively, from 5 times to 10 times
the mass of the ***thiol*** ester.

DETD In some aspects the conversion of the ***thiol*** group to
the thioacrylate group occurs in the presence of a catalyst. In some
embodiments, the catalyst is homogeneous. In some embodiments,
the catalyst is an organic amine. Examples of suitable organic amines
include triethylamine, tripropylamine, tributylamine, and
pyridine. In other embodiments, the catalyst is heterogeneous. Examples of
suitable catalysts include Amberlyst A-21 and Amberlyst A-26. Other
suitable catalysts will be apparent to those of skill in the art and are
to be considered within the scope of the present invention.

DETD The conversion of the ***thiol*** group to a thioacrylate
group can be performed at any conversion temperature that is capable of
converting the ***thiol*** group to a thioacrylate group. In some
embodiments, the conversion temperature is greater than -20.degree. C. In
other embodiments, the conversion temperature is greater than 0.degree.
C.; alternatively, greater than 20.degree. C.; alternatively, greater
than 50.degree. C.; alternatively, greater than 80.degree. C.; or
alternatively, greater than 100.degree. C. In yet other
embodiments, the conversion temperature ranges from -20.degree. C. to 250.degree.
C.; alternatively, from 20.degree. C. to 200.degree. C.; or
alternatively, from 50.degree. C. to 150.degree. C.

DETD The conversion time required for the conversion of the
thiol
group to a thioacrylate group can be any time required to form
the
described thioacrylate containing ester. Generally, the
conversion time
is at least 5 minutes. In some embodiments, the conversion time
is at
least 15 minutes; alternatively, at least 30 minutes;
alternatively, at
least 45 minutes; or alternatively, at least 1 hour. In other
embodiments, the conversion time ranges from 15 minutes to 12
hours;
alternatively, from 30 minutes to 6 hours; or alternatively, from
45
minutes to 3 hours.

DETD The conversion of the ***thiol*** group to a thioacrylate
group can
be performed at any conversion pressure that maintains the
thiol
ester and the acrylate compound in the liquid state. In some
embodiments, the conversion pressure ranges from 0 psia to 2000
psia. In
other embodiments, the conversion pressure ranges from 0 psia to
1000
psia; or alternatively, from 0 psia to 500 psia.

DETD Process for Producing Cross-Linked ***Thiol*** Ester
DETD As an embodiment of the present invention, a process for
producing a
cross-linked ***thiol*** ester composition is advantageously
provided. Minimally, in some embodiments, the process to produce
the
cross-linked ***thiol*** ester composition comprises
contacting a
thiol ester composition with an oxidizing agent and
reacting the
thiol ester composition and an oxidizing agent to form
the
thiol ester oligomer having at least two ***thiol***
ester
monomers connected by a polysulfide linkage having the structure
--S.sub.Q-- , wherein Q is an integer greater than 1. The
disclosed
method may be applied to any ***thiol*** ester described
herein to
produce any cross-linked ***thiol*** ester composition as
described
herein. The process to produce the cross-linked ***thiol***
ester
composition can also include any additional process steps or
process
conditions as described herein.

DETD When elemental sulfur is used as the oxidizing agent, the
quantity of
elemental sulfur utilized to form the cross-linked ***thiol***
ester
composition is determined as a function of the ***thiol***
sulfur
content of the ***thiol*** ester composition. In an aspect,
the

weight ratio of elemental sulfur to ***thiol*** sulfur in the
thiol ester composition is at least 0.5. In some
embodiments,
the weight ratio of elemental sulfur to ***thiol*** sulfur in
the ***thiol*** ester composition is at least 5; alternatively,
at least 10, alternatively, at least 15, or alternatively, at least 20. In
other
embodiments, the weight ratio of elemental sulfur to
thiol
sulfur in the ***thiol*** ester composition ranges from 0.5
to 32; alternatively, ranges from 1 to 24; alternatively, ranges from 2
to 16;
or alternatively, ranges from 3 to 10.
DETD In an aspect, the reaction of the ***thiol*** ester and
elemental
sulfur occurs in the presence of a catalyst. The catalyst can be
any
catalyst that catalyzes the formation of the polysulfide linkage
between
at least two ***thiol*** ester monomers. In some embodiments,
the
catalyst is an amine. In further embodiments, the catalyst is a
tertiary
amine.
DETD The formation of the cross-linked ***thiol*** ester can
occur in a
batch reactor or a continuous reactor, as described herein. The
formation of the cross-linked ***thiol*** ester can occur at
any
temperature capable of forming the ***thiol*** ester. In some
embodiments, the formation of the cross-linked ***thiol***
ester can
occur at a temperature greater than 25.degree. C. In other
embodiments,
the formation of the cross-linked ***thiol*** ester can
occur
at a
temperature greater than 50.degree. C.; alternatively, greater
than
70.degree. C.; or alternatively, greater than 80.degree. C. In
yet other
embodiments, the formation of the cross-linked ***thiol***
ester
occurs at a temperature from 25.degree. C. to 150.degree. C.;
alternatively, from 50.degree. C. to 150.degree. C.;
alternatively, from
70.degree. C. to 120.degree. C.; or alternatively, from
80.degree. C. to
110.degree. C.
DETD The time required to form the cross-linked ***thiol*** ester
can be
any time required to form the desired cross-linked ***thiol***
ester. Generally, the time required to form the cross-linked
thiol ester is at least 15 minutes. In some
embodiments, the
time required to form the cross-linked ***thiol*** ester is
at least
30 minutes; alternatively, at least 1 hour; or alternatively, at

least 2 hours. In yet other embodiments, the time required to form the cross-linked ***thiol*** ester ranges from 15 minutes to 72 hours; alternatively, from 30 minutes to 48 hours; alternatively, from 1 hour minutes to 36 hours; or alternatively, from 2 hours and 24 hours. DETD In embodiments, the process to produce the cross-linked ***thiol*** ester further comprises a step to remove residual hydrogen sulfide. In some embodiments the cross-linked ***thiol*** ester is vacuum stripped. In some embodiments, the cross-linked ***thiol*** ester is vacuum striped at a temperature between 25.degree. C. and 250.degree. C.; alternatively, between 50.degree. C. and 200.degree. C.; or alternatively, 75 and 150.degree. C. In some embodiments, the cross-linked ***thiol*** ester oil is sparged with an inert gas to remove residual hydrogen sulfide. In other embodiments, the cross-linked ***thiol*** ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; alternatively, between 50.degree. C. and 200.degree. C.; or alternatively, between 75 and 150.degree. C. In yet other embodiments, the vacuum stripping is performed while sparging the cross-linked ***thiol*** ester with an inert gas. In yet other embodiments, the vacuum stripping is performed while sparging the cross-linked ***thiol*** ester an inert gas at a temperature between 25.degree. C. and 250.degree. C.; alternatively, between 50.degree. C. and 200.degree. C.; or alternatively, 75 and 150.degree. C. In some embodiments, the inert gas is nitrogen. DETD Generally, the stripped or sparged cross-linked ***thiol*** ester comprises less than 0.1 weight percent hydrogen sulfide. In other embodiments, the stripped or sparged ***thiol*** -containing ester oil comprises less than 0.05 weight percent hydrogen sulfide; alternatively, less than 0.025 weight percent hydrogen sulfide; or alternatively, less than 0.01 weight percent hydrogen sulfide. DETD The present invention advantageously provides processes for producing sulfide-containing esters as embodiments of the present invention. Generally, the sulfide-containing esters can be prepared by two processes. As an embodiment of the present invention, the first process used to produce a sulfide-containing ester comprises contacting an unsaturated ester and a ***mercaptan*** and reacting the unsaturated ester and ***mercaptan*** to form a sulfide-containing ester.

As another embodiment of the present invention, the second process used to produce a sulfide-containing ester comprises contacting an epoxidized unsaturated ester and a ***mercaptan*** sulfide and reacting the unsaturated ester and ***mercaptan*** to form a sulfide-containing ester. Additional aspects of the two sulfide-containing ester production processes are described below.

DETD The sulfide-containing esters and sulfide-containing ester compositions described herein can be produced by a process comprising contacting a ***mercaptan*** and an unsaturated ester and reacting the ***mercaptan*** and the unsaturated ester to form a sulfide-containing ester. The process can be applied to any of the unsaturated esters and ***mercaptans*** described herein. The process for producing the sulfide-containing ester can also include any additional process steps or process conditions described herein. Additionally, the process for producing the sulfide-containing ester can form any sulfide-containing ester described herein.

DETD In some aspects, the reaction between the ***mercaptan*** and the unsaturated ester occurs in the presence of a solvent. In other aspects the reaction between the ***mercaptan*** and the unsaturated ester occurs in the substantial absence of a solvent. When the reaction occurs in the presence of a solvent, the solvent is selected from an aliphatic hydrocarbon, an ether, an aromatic compound, an alcohol, or any combination thereof. Generally, the solvent, regardless of its chemical class, can comprise from 1 to 20 carbon atoms; alternatively, from 3 to 10 carbon atoms. When the solvent includes an aliphatic hydrocarbon, the aliphatic hydrocarbon is butane, isobutane, pentane, hexane, heptane, octane, or any mixture thereof. When the solvent includes an aromatic compound, the aromatic compound is benzene, toluene, xylene, ethylbenzene, or any mixture thereof. When the solvent includes an alcohol, the alcohol is methanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol, 2-methyl-2-propanol, or any mixture thereof. When the solvent includes an ether, the ether is diethyl ether, dipropyl ether, tetrahydrofuran, or any mixture thereof.

DETD When a solvent is used for the reaction between the
 mercaptan
 and the unsaturated ester, the quantity of solvent can be any
 amount that facilitates the reaction, as understood by those of skill in
 the art. In some embodiments, the mass of the solvent is less than 30
 times the mass of the unsaturated ester. In other embodiments, the mass
 of the solvent is less than 20 times the mass of the unsaturated ester;
 alternatively, less than 15 times the mass of the unsaturated
 ester; alternatively, less than 10 times the mass of the unsaturated
 ester; or alternatively, less than 5 times the mass of the unsaturated
 ester. In other embodiments, the mass of the solvent is from 2 times to 20
 times the mass of the unsaturated ester; alternatively, from 3 times to
 15 times the mass of the unsaturated ester; alternatively, from 4
 times to 15 times the mass of the unsaturated ester; or alternatively,
 from 5 times to 10 times the mass of the unsaturated ester.

DETD The molar ratio of ***mercaptan*** to molar equivalents of
 unsaturated ester carbon-carbon double bonds (herein after "
 mercaptan to carbon-carbon double bond molar ratio")
 utilized in the process to produce the sulfide-containing ester can be any
 mercaptan to carbon-carbon double bond molar ratio that
 produces the desired sulfide-containing ester. The molar equivalents of
 unsaturated ester carbon-carbon double bonds is calculated by the
 equation: $\frac{UES}{MW} \times CDB$ In this equation, UES is the average
 gram molecular weight of the unsaturated ester, UES Mass is the mass
 of the unsaturated ester, and UES C.dbd.C is the average number of
 double bonds per unsaturated ester molecule. In some embodiments, the
 mercaptan to carbon-carbon double bond molar ratio is
 greater than 0.25. In other embodiments, the ***mercaptan*** to
 carbon-carbon double bond molar ratio is greater than 0.5;
 alternatively, greater than 0.75; alternatively, greater than 1;
 alternatively, greater than 1.25; or alternatively, greater than
 1.5. In other embodiments, the ***mercaptan*** to carbon-carbon
 double bond molar ratio can range from 0.25 to 2; alternatively, from 0.5 to
 1.5, or alternatively, from 0.75 to 1.25.

DETD In some aspects the reaction between the ***mercaptan*** and
 the unsaturated ester is catalyzed. The reaction of the
 mercaptan
 and the unsaturated ester can be catalyzed by a heterogeneous
 catalyst

or homogeneous catalyst, as described herein. In some aspects, the reaction between the ***mercaptan*** and the unsaturated ester is initiated by a free radical initiator or ultraviolet radiation, as described herein.

DETD The free radical initiator can be any free radical initiator capable of forming free radicals under thermal or light photolysis. Generally, the free radical initiator is selected from the general class of compounds having a --N.dbd.N-- group or a --O--O-- group. Specific classes of free radical initiators include diazo compounds, dialkyl peroxides, hydroperoxides, and peroxy esters. Specific initiators include azobenzene, 2,2'-azobis(2-methylpropionitrile, 4,4'-azobis(4-cyanovaleric acid), 1,1'-azobis(cyclohexanecarbonitrile), 2,2'-azobis(2methylpropane), 2,2'-azobis(2-methylpropionamidine) dihydro-chloride, methylpropionitrile, azodicarboxamide, tert-butyl hydroperoxide, di-tert-butyl peroxide, octylperbenzoate. In some embodiments, the free radical initiated reaction of the ***mercaptan*** and the unsaturated ester is performed at a reaction temperature within ± 50 degree. C. of the 1 hour half life of the free radical initiator. In other embodiments, the reaction temperature is within ± 25 degree. C. of the 1 hour half life of the free radical initiator; alternatively, the reaction temperature is within ± 20 degree. C. of the 1 hour half life of the free radical initiator; alternatively, the reaction temperature is within ± 15 degree. C. of the 1 hour half life of the free radical initiator; or alternatively, the reaction temperature is within ± 10 degree. C. of the 1 hour half life of the free radical initiator. In embodiments where the free radical initiated reaction of the ***mercaptan*** and the unsaturated ester is initiated by light photolysis, the light can be any light capable creating free radicals. In some embodiments, the light is UV radiation. Other sources of light capable of creating free radicals will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD In another aspect, the reaction of the ***mercaptan*** and the unsaturated ester is initiated by UV radiation. In these embodiments, the UV radiation may be any UV radiation capable of initiating the reaction of the ***mercaptan*** and the unsaturated ester. In

some embodiments, the UV radiation is generated by a medium pressure mercury lamp.

DETD The reaction of the ***mercaptan*** and the unsaturated ester can occur in a batch reactor of a continuous reactor. Any of the batch or continuous reactors described herein can be used in this reaction. Other suitable reactors will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD The reaction time for reacting the ***mercaptan*** and the unsaturated ester can be any time required to form the sulfide-containing ester. Generally, the reaction time is at least 5 minutes. In some embodiments, the reaction time ranges from 5 minutes to 72 hours; alternatively, from 10 minutes to 48 hours; or alternatively, from 15 minutes to 36 hours.

DETD In some embodiments, the process to produce the sulfide-containing ester further comprises a step to remove any residual ***mercaptan*** that remains after reacting the ***mercaptan*** and the unsaturated ester. In some embodiments, the sulfide-containing ester is vacuum stripped to remove the residual ***mercaptan***. In some embodiments, the sulfide-containing ester is vacuum stripped at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the sulfide-containing ester is sparged with an inert gas to remove the residual ***mercaptan***. In some embodiments, the sulfide-containing ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In some aspects, the inert gas is nitrogen. Generally, the stripped or sparged sulfide-containing ester comprises less than 5 weight percent of the ***mercaptan***. In other embodiments, the stripped or sparged sulfide-containing ester comprises less than 2 weight percent of the ***mercaptan***; alternatively, less than 1 weight percent of the ***mercaptan***; or alternatively, less than 0.5 weight percent of the ***mercaptan***.

DETD The reaction between the ***mercaptan*** and the unsaturated ester can be performed at any temperature capable of forming the sulfide-containing ester. In some embodiments, the

mercaptan
and the unsaturated ester can be reacted at a reaction temperature of greater than -20.degree. C. In other embodiments, the reaction temperature is greater than 0.degree. C.; alternatively, greater than 20.degree. C.; alternatively, greater than 50.degree. C.; alternatively, greater than 80.degree. C.; or alternatively, greater than 100.degree. C. In yet other embodiments, the ***mercaptan*** and the unsaturated ester can be reacted at a temperature from -20.degree. C. to 250.degree. C.; alternatively, from 20.degree. C. to 200.degree. C.; or alternatively, from 80.degree. C. to 160.degree. C.

DETD The reaction between the ***mercaptan*** and the unsaturated ester can be performed at any pressure that maintains the ***mercaptan*** and the unsaturated ester in a substantially liquid state. In some embodiments, the ***mercaptan*** and the unsaturated ester can be performed at a reaction pressure ranging from 0 psig to 2000 psig. In other embodiments, the reaction pressure ranges from 0 psig to 1000 psig; alternatively, from 0 psig to 500 psig; or alternatively, from 0 psig to 200 psig.

DETD Using the disclosed process, sulfide-containing ester having a low carbon-carbon double bond to sulfide group molar ratio can be produced. In an aspect, the process for producing the sulfide-containing ester forms a sulfide-containing ester having a carbon-carbon double bond to ***thiol*** group molar ratio of less than 1.5. Additional carbon-carbon double bond to sulfide group molar ratios are disclosed herein.

DETD As another embodiment of the present invention, another process for producing a class of sulfide-containing esters, which includes hydroxy sulfide-containing esters, is advantageously provided. In this embodiment, the hydroxy sulfide-containing esters and hydroxy sulfide-containing ester compositions can be produced by a process comprising the steps of contacting a ***mercaptan*** and an epoxidized unsaturated ester and reacting the ***mercaptan*** and the epoxidized unsaturated ester to produce or form the hydroxy sulfide-containing ester. The process can be applied to any ***mercaptan*** and/or any epoxidized unsaturated esters described herein. The process for producing the hydroxy sulfide-containing ester

can also include any additional process steps or process conditions as described herein. Additionally, the process for producing the hydroxy sulfide-containing ester can form any hydroxy sulfide-containing ester as described herein.

DETD In some aspects, the reaction between the ***mercaptan*** and the unsaturated ester occurs in the presence of a solvent. In other aspects the reaction between the ***mercaptan*** and the unsaturated ester occurs in the substantial absence of a solvent. When the reaction occurs in the presence of a solvent, the solvent is selected from an aliphatic hydrocarbon, an ether, an aromatic compound, or any combination thereof.

Generally, the solvent, regardless of its chemical class, can comprise from 1 to 20 carbon atoms; alternatively, from 3 to 10 carbon atoms.

When the solvent includes an aliphatic hydrocarbon, the aliphatic hydrocarbon is butane, isobutane, pentane, hexane, heptane, octane, or any mixture thereof. When the solvent includes an aromatic compound, the aromatic compound is benzene, toluene, xylene, ethylbenzene, or any mixture thereof. When the solvent includes an ether, the ether is diethyl ether, dipropyl ether, tetrahydrofuran, or any mixture thereof.

DETD When a solvent is used for the reaction between the ***mercaptan*** and the epoxidized unsaturated ester, the quantity of solvent can be any amount that facilitates the reaction, as understood by those of skill in the art. In some embodiments, the mass of the solvent is less than 30 times the mass of the epoxidized unsaturated ester. In other embodiments, the mass of the solvent is less than 20 times the mass of the epoxidized unsaturated ester; alternatively, less than 15 times the mass of the epoxidized unsaturated ester; alternatively, less than 10 times the mass of the epoxidized unsaturated ester; or alternatively, less than 5 times the mass of the epoxidized unsaturated ester.

In other embodiments, the mass of the solvent is from 2 times to 20 times the mass of the epoxidized unsaturated ester; alternatively, from 3 times to 15 times the mass of the epoxidized unsaturated ester; alternatively, from 4 times to 15 times the mass of the epoxidized unsaturated ester;

or alternatively, from 5 times to 10 times the mass of the epoxidized unsaturated ester.

DETD The reaction of the ***mercaptan*** and the epoxidized unsaturated ester can occur using any ***mercaptan*** to molar equivalents of ***epoxide*** groups in the epoxidized unsaturated ester (hereinafter referred to as " ***mercaptan*** to ***epoxide*** group molar ratio") that is capable of producing the herein described .alpha.-hydroxy ***thiol*** esters. The molar equivalents of epoxidized unsaturated ester epoxidized groups can be calculated by the equation: ##EQU4##

DETD In this equation, EUES GMW is the average gram molecular weight of the epoxidized unsaturated ester, EUES Mass is the mass of the epoxidized unsaturated ester, and EUES ***Epoxide*** is the average number of ***epoxide*** groups per epoxidized unsaturated ester molecule. In some embodiments, the ***mercaptan*** to ***epoxide*** group molar ratio is greater than 0.2. In other embodiments, the ***mercaptan*** to ***epoxide*** group molar ratio is greater than 0.5; alternatively, greater than 1; or alternatively, greater than 2. In other embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio ranges from 0.2 to 10; alternatively, from 0.5 to 8; alternatively, from 0.75 to 5; or alternatively, from 1 to 3.

DETD In some aspects, the reaction of the ***mercaptan*** and the epoxidized unsaturated ester occurs in the presence of a catalyst. Generally, the catalyst is any catalyst that is capable of catalyzing the reaction of the ***mercaptan*** and the epoxidized unsaturated ester to produce the desired hydroxy ***thiol*** ester. In one aspect, the catalyst is selected from the group consisting of homogeneous and heterogeneous catalysts. In other aspects, the catalyst is selected from the group consisting of zeolites, heterogeneous catalysts, homogeneous catalysts, and mixtures thereof. In another aspect, the catalyst is an amine. In other aspects, the catalyst is selected from the group consisting of cyclic conjugated amines, 1,8-diazabicyclo[5.4.0]undec-7-ene, 1,5-diazabicyclo[4.3.0]non-5-ene, and mixtures thereof.

DETD In some aspects, the reaction of the ***mercaptan*** and the epoxidized unsaturated ester occurs in the presence of a catalyst. Generally, the catalyst is any catalyst that is capable of

catalyzing the reaction of the ***mercaptan*** and the epoxidized unsaturated ester to produce the desired hydroxy ***thiol*** ester. In some embodiments the catalyst is an organic base. In some embodiments, the catalyst can be 1,8-diazabicyclo[5.4.0]undec-7-ene. (What other catalysts may be used?)

DETD The reaction of the ***mercaptan*** and the epoxidized unsaturated ester can occur in a batch reactor or a continuous reactor. Any of the batch or continuous reactors described herein can be used in this reaction. Other suitable reactors will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD The time required for the reaction of the ***mercaptan*** and the epoxidized unsaturated ester can be any reaction time required to form the described hydroxy sulfide-containing ester. Generally, the reaction time is at least 15 minutes. In some embodiments, the reaction time ranges from 15 minutes to 72 hours; alternatively, from 30 minutes to 48 hours; or alternatively, from 45 minutes to 36 hours.

DETD In some embodiments, the process to produce the hydroxy sulfide-containing ester further comprises a step to remove the residual ***mercaptan*** after reacting the ***mercaptan*** and the epoxidized unsaturated ester. In some embodiments the hydroxy sulfide-containing ester is vacuum stripped. In some embodiments, the hydroxy sulfide-containing ester is vacuum stripped at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the hydroxy sulfide-containing ester is sparged with an inert gas to remove the ***mercaptan***. In some embodiments, the hydroxy sulfide-containing ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In some aspects, the inert gas is nitrogen. Generally, the stripped or sparged hydroxy sulfide-containing ester comprises less than 5 weight percent of the ***mercaptan***. In other embodiments, the stripped or sparged hydroxy sulfide-containing ester comprises less than 2 weight percent of the ***mercaptan***; alternatively,

less than 1 weight percent of the ***mercaptan*** ; or alternatively, less than 0.5 weight percent of the ***mercaptan*** .

DETD The reaction between the ***mercaptan*** and the epoxidized unsaturated ester can be performed at any reaction temperature capable of forming the hydroxy sulfide-containing ester. In some embodiments, the reaction temperature is greater than -20.degree. C. In other embodiments, the reaction temperature is greater than 0.degree. C.; alternatively, greater than 20.degree. C.; alternatively, greater than 50.degree. C.; or alternatively, greater than 80.degree. C. In yet other embodiments, the reaction temperature ranges from -20.degree. C. to 200.degree. C.; alternatively, from 20.degree. C. to 170.degree. C.; or alternatively, from 80.degree. C. to 140.degree. C.

DETD The reaction between the ***mercaptan*** and the epoxidized unsaturated ester can be performed at any reaction pressure that maintains the ***mercaptan*** and the epoxidized unsaturated ester in a substantially liquid state. In some embodiments, the reaction pressure ranges from 0 psig to 2000 psig. In other embodiments, the reaction pressure ranges from 0 psig to 1000 psig; alternatively, from 0 psig to 500 psig; or alternatively, from 0 psig to 200 psig.

DETD In another aspect, the process to produce a hydroxy sulfide-containing ester produces a hydroxy sulfide-containing ester having an ***epoxide*** group to sulfide group molar ratio less than 2.

Other hydroxy sulfide-containing ester ***epoxide*** group to sulfide group molar ratios are described herein. (The next passage needs to be incorporated into the hydroxy ***thiol*** ester section along with the first sentence of this paragraph.) Alternatively, the hydroxy sulfide-containing ester ***epoxide*** group to ***thiol*** group molar ratio can be less than 1.5; alternatively, less than 1.0; alternatively, less than 0.5; alternatively, less than 0.25; or alternatively, less than 0.1. In other embodiments, the hydroxy sulfide-containing ester can be substantially free of ***epoxide*** groups.

DETD As an embodiment of the present invention, processes for producing a sulfonic acid-containing ester and for producing a sulfonate-containing ester are advantageously provided. Generally, the process for producing the sulfonic acid-containing ester comprises the steps of contacting a

least one ***thiol*** ester and an oxidizing agent and oxidizing at
sulfonic ***thiol*** group of the ***thiol*** ester to produce a
acid group. The process for producing the sulfonate-containing
ester comprises the steps of contacting a sulfonic acid-containing
ester with a base and forming a sulfonate-containing ester.
DETD In an embodiment, the process to prepare a sulfonic acid-
containing ester comprises the steps of contacting the ***thiol*** ester
and the oxidizing agent and oxidizing the ***thiol*** ester to
produce the sulfonic acid-containing ester. Generally the oxidizing agent
oxidizes at least one ***thiol*** group of the ***thiol***
ester to a sulfonate group. The process to produce the sulfonic
acid-containing ester composition can be applied to any
thiol
ester described herein to prepare any sulfonic acid-containing
ester described herein. In some embodiments, the ***thiol*** ester
includes a hydroxy group. For example, the ***thiol*** ester
can be any hydroxy ***thiol*** ester described herein. The oxidizing
agent can be any oxidizing agent described herein.
DETD In some aspects, the oxidation of the ***thiol*** ester
occurs in the presence of a solvent. In some aspects, the solvent is water.
DETD The oxidizing agent that is contacted with the ***thiol***
ester can be any oxidizing agent capable of oxidizing a ***thiol***
group to a sulfonic acid group. In some embodiments, the oxidizing
agent is oxygen. In other embodiments, the oxidizing agent is chlorine. In
other embodiments, the oxidizing agent is dimethyl sulfoxide. In yet
other embodiments, the oxidizing agent is a combination of a hydrogen
halide and a catalytic amount of a dialkyl sulfide, such as dimethyl
sulfoxide.
Other suitable oxidizing agents will be apparent to those of
skill in the art and are to be considered within the scope of the present
invention.
DETD The oxidation of the ***thiol*** ester can be performed at
any temperature capable of converting the ***thiol*** ester to a
sulfonic acid-containing ester. In some embodiments, the
thiol
ester is oxidized at a temperature greater than -20.degree. C. In
other embodiments, the ***thiol*** ester is oxidized at a
temperature greater than 0.degree. C.; alternatively, greater than 20.degree. C.

C.; or
alternatively, greater than 50.degree. C.
DETD The time required for the oxidation of the ***thiol*** ester
can be
any time required to form the desired sulfonic acid-containing
ester.
Generally, the time required for the oxidation of the
thiol
ester is at least 15 minutes; alternatively, at least 30 minutes;
alternatively, at least 45 minutes; or alternatively, at least 1
hour.
In some embodiments, the time required for the oxidation of the
thiol ester ranges from 15 minutes to 12 hours;
alternatively,
from 30 minutes to 6 hours; alternatively, from 45 minutes to 3
hours.
DETD The oxidation of the ***thiol*** ester can be performed at
any
pressure that maintains the ***thiol*** ester and the
oxidation
agent in the proper state, which is not always a liquid state, to
oxidize the ***thiol*** ester to a sulfonic acid-containing
ester.
For example, when the oxidation agent is chlorine, the chlorine
can be
in the gaseous state. In some embodiments, the oxidation of the
thiol ester can performed at a pressure ranging from 0
psig to
2000 psig. In other embodiments, the oxidation of the
thiol
ester can be performed at a pressure ranging from 0 to 1000 psig;
or
alternatively, 0 to 500 psig.
DETD The oxidation of the ***thiol*** ester can be performed in a
batch
reactor or a continuous reactor, as described herein.
Additionally, the
process to produce the sulfonic acid-containing ester can
comprise
additional process steps as recognized by those skilled in the
art.
DETD The formation of the sulfonate-containing ester can be performed
at any
temperature capable of converting the sulfonic acid group of the
sulfonic acid-containing ester to a sulfonate group. In some
embodiments, the sulfonate-containing ester is formed at a
temperature
greater than -20.degree. C. In other embodiments, the
thiol
ester is oxidized at a temperature greater than 0.degree. C.;
alternatively, greater than 20.degree. C.; or alternatively,
greater
than 50.degree. C. In yet other embodiments, the ***thiol***
ester
is oxidized at a temperature ranging from 0.degree. C. to
250.degree.
C.; alternatively, from 0.degree. C. to 150.degree. C.; or
alternatively, from 20.degree. C. to 100.degree. C.
DETD A preferred sulfur-containing vegetable oil is MVO available
from

Chevron Phillips Chemical Co. under the tradename Polymercaptan 358. Polymercaptan 358 is made by the free radical addition of hydrogen sulfide to the double bonds in soybean oil. Typically, Polymercaptan 358 has a **thiol** sulfur content of 5 to 10% and equivalent weights of 640 to 320, respectively.

DETD Another preferred sulfur-containing vegetable oil useful as part of the isocyanate-reactive component is a MHVO such as mercapto-hydroxy soybean oil. As described herein, a preferred mercapto-hydroxy soybean oil is made by the free radical addition of hydrogen sulfide to epoxidized soybean oil. Typically, the mercapto and hydroxy functionalities are equal and the **mercaptan** content is about 8.3% **thiol** sulfur. The equivalent weight of this material is 192, which includes both mercapto and hydroxy functionalities.

DETD Yet another preferred sulfur-containing vegetable oil useful as part of the isocyanate-reactive component is a CMVO such as sulfur cross-linked mercaptanized soybean oil. Sulfur cross-linked mercaptanized soybean oil is made by the addition of elemental sulfur to mercaptanized soybean oil. In this process, a portion of the **mercaptan** groups are consumed as cross-linking sites for the sulfur. Typical sulfur cross-linked mercaptanized soybean oil products by Chevron Phillips Chemical Co. include Runs #22, 194, 195, 196 and 197 and have a **thiol** sulfur content ranging from about 8.0% to 1.4% and equivalent weights ranging from about 400 to about 2250, respectively.

DETD For epoxy polymer encapsulated CRF material made from sulfur-containing vegetable oil, it has been found that the use of a tertiary amine catalyst is highly preferred. The amount used is such to be sufficient to give the desired reaction rate for the production of the encapsulated slow release fertilizer product. A non-limiting example of a suitable amine catalyst is diazobicycloundecacene also known as 1,8-diazabicyclo[5,4,0]undec-7-ene [CAS# **6674-22-2**] or "DBU", which is preferably used in the range of about 0.1% to 0.5% by weight of the coating. Other suitable catalyst materials will be apparent to those of ordinary skill in the art.

DETD The preferred sulfur-containing vegetable oil to be used in

production
of an epoxy polymer coated CRF material is MHVO such as mercapto-
hydroxy soybean oil. One such material is mercapto-hydroxy soybean oil
known as
MHSO 566-84 produced by Chevron Phillips Chemical Co. This
preferred
material contains 8.33% ***thiol*** sulfur, with an
equivalent
weight of 384, based upon the ***mercaptan*** functionality.
DETD The unsaturated ester used as a feedstock to produce the
thiol
ester compositions described herein can be described using a
number of
different methods. One method of describing the unsaturated ester
feedstock is by the number of ester groups and the number of
carbon-carbon double bonds that comprise each unsaturated ester
oil
molecule. Suitable unsaturated ester used as a feedstock to
produce the
thiol ester compositions described herein minimally
comprise at
least 1 ester group and at least 1 carbon-carbon double bond.
However,
beyond this requirement, the number of ester groups and carbon-
carbon
double bonds comprising the unsaturated esters are independent
elements
and can be varied independently of each other. Thus, the
unsaturated
esters can have any combination of the number of ester groups and
the
number of carbon-carbon double bonds described separately herein.
Suitable, unsaturated esters can also contain additional
functional
groups such as alcohol, aldehyde, ketone, epoxy, ether, aromatic
groups,
and combinations thereof. As an example, the unsaturated esters
can also
comprise hydroxy groups. An example of an unsaturated ester that
contains hydroxy groups is castor oil. Other suitable unsaturated
esters
will be apparent to those of skill in the art and are to be
considered
within the scope of the present invention.
DETD In yet another aspect, the polyol or mixture of polyols used to
produce
the unsaturated ***thiol*** ester has a molecular weight or
average
molecular weight less than 500. In other embodiments, the polyol
or
mixture of polyols have a molecular weight or average molecular
weight
less than 300; alternatively less than 200; alternatively, less
than
150; or alternatively, less than 100.
DETD Specific carboxylic acids used as a component of the carboxylic
acid
composition used to produce the unsaturated ester oil can have
from 3 to

30 carbon atoms per carboxylic acid molecule. In some embodiments the carboxylic acid is linear. In some embodiments the carboxylic acid is branched. In some embodiments the carboxylic acid is a mixture of linear and branched carboxylic acids. In some embodiments the carboxylic acid can also comprise additional functional groups including alcohols, aldehydes, ketones, and ***epoxides***, among others.

DETD Minimally, the epoxidized unsaturated ester comprises at least one ***epoxide*** group. In an embodiment the epoxidized unsaturated ester comprises at least 2 ***epoxide*** groups; alternatively, at least 3 ***epoxide*** groups; or alternatively, at least 4 ***epoxide*** groups.

In other embodiments, the epoxidized unsaturated ester comprises from 2 to 9 ***epoxide*** groups; alternatively, from 2 to 4 ***epoxide*** groups; alternatively, from 3 to 8 ***epoxide*** groups; or alternatively, from 4 to 8 ***epoxide*** groups.

DETD In some embodiments, the unsaturated ester comprises a mixture of epoxidized unsaturated esters. In this aspect, the number of ***epoxide*** groups in the epoxidized unsaturated ester is best described as an average number of ***epoxide*** groups per epoxidized unsaturated ester molecule. In some embodiments, the epoxidized unsaturated esters have an average of at least 1.5 ***epoxide*** groups per epoxidized unsaturated ester molecule; alternatively, an average of at least 2 ***epoxide*** groups per epoxidized unsaturated ester molecule; alternatively, an average of at least 2.5 ***epoxide*** groups per epoxidized unsaturated ester molecule; or alternatively, an average of at least 3 ***epoxide*** groups per epoxidized unsaturated ester molecule. In other embodiments, the epoxidized unsaturated esters have average of from 1.5 to 9 ***epoxide*** groups per epoxidized unsaturated ester molecule; alternatively, an average of from 3 to 8 ***epoxide*** groups per epoxidized unsaturated ester molecule; alternatively, an average of from 2 to 4 ***epoxide*** groups per epoxidized unsaturated ester molecule; or alternatively, from of 4 to 8 ***epoxide*** groups per epoxidized unsaturated ester molecule.

DETD The ***thiol*** composition can include an average of greater than 0 to about 4 ***epoxide*** groups per triglyceride. The ***thiol*** composition can also include an average of

greater than 1.5 to about 9 ***epoxide*** groups per triglyceride.

DETD ***Mercaptans***

DETD Within some embodiments, an unsaturated ester or an epoxidized unsaturated ester is contacted with ***mercaptan***. Within these embodiments, the ***mercaptan*** can be any ***mercaptan*** comprising from 1 to 20 carbon atoms. Generally, the ***mercaptan*** can have the following structure: $\text{HS}-\text{R}_{\text{sup.3}}$ wherein R₃ is a C1 to C20 organyl groups or a C1 to C20 hydrocarbyl groups. In further embodiments the R₃ can be a C2 to C10 organyl group or a C2 to C10 hydrocarbyl group. In some embodiments, the ***mercaptan*** composition comprises a solvent. In one aspect, the ***mercaptan*** composition comprises at least one other functional group.

DETD The at least one other functional group can be selected from several different groups. For example, the at least one other functional group is an alcohol group, a carboxylic alcohol group, a carboxylic ester group, an amine group, a sulfide group, a ***thiol*** group, a methyl or ethyl ester of a carboxylic acid group, or combinations thereof. Other types of functional groups will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD In some embodiments, the ***mercaptan*** is selected from the group consisting of 3-mercaptopropyl-trimethoxysilane, 2-mercaptopyridine, 4-mercaptopyridine, 2-mercaptopyrimidine, mercaptopyruvic acid, mercaptosuccinic acid, 2-mercaptonicotinic acid, 6-mercaptonicotinic acid, 2-mercaptophenol, 4-mercaptophenol, 3-mercapto-1,2-propanediol, 3-mercapto-1,2-propanediol, 3-mercapto-1-propanesulfonic acid, 1-mercapto-2-propanol, 3-mercapto-1-propanol, 2-mercaptopropionic acid, 3-mercaptopropionic acid, 2-mercaptobenzyl alcohol, 3-mercapto-2-butanol, 4-mercapto-1-butanol, 2-mercaptoethanesulfonic acid, 2-mercaptoethanol, 2-mercaptoethyl ether, 2-mercaptoethyl sulfide, 16-mercaptohexadecanoic acid, 6-mercapto-1-hexanol, 4'-mercaptoacetanilide, mercaptoacetic acid, 2-mercaptobenzoic acid, 3-mercaptobenzoic acid, 4-mercaptobenzoic acid, 2-mercaptothiazoline, 3-mercapto-1H-1,2,4-triazole, 11-mercaptoundecanoic acid, 11-mercapto-1-undecanol, or combinations thereof.

DETD In some embodiments, the ***mercaptan*** is selected from the group consisting of beta-mercaptoethanol, 2-mercaptophenol, 3-mercaptophenol, 4-mercaptophenol, 1-mercapto-2-propanol, 1-mercapto-3-propanol,

mercaptoacetic acid, 2-mercaptopropionic acid, 3-mercaptopropionic acid, 2-mercaptobenzoic acid, 3-mercaptobenzoic acid, 4-mercaptobenzoic acid, 2-mercaptobenzylalcohol, 3-mercapto-2-butanol, 4-mercapto-1-butanol, 2-mercaptoethyl ether, 2-mercaptoethyl sulfide, 6-mercapto-hexanol, 3-mercapto-1,2-propanediol, mercaptosuccinic acid, and mixtures thereof.

In further embodiments, the ***mercaptan*** is selected from the

group consisting of beta-mercaptoethanol, 1-mercapto-2-propanol, 1-mercapto-3-propanol, 2-mercaptobenzylalcohol, 3-mercapto-2-butanol,

4-mercapto-1-butanol, 6-mercapto-hexanol, 3-mercapto-1,2-propanediol,

and mixtures thereof. In further embodiments, the

mercaptan is selected from the group consisting 2-mercaptophenol, 3-mercaptophenol,

4-mercaptophenol, and mixtures thereof. In yet further embodiments, the

mercaptan is selected from the group consisting mercaptoacetic acid, 2-mercaptopropionic acid, 3-mercaptopropionic acid, 2-mercaptobenzoic acid, 3-mercaptobenzoic acid, 4-mercaptobenzoic acid, mercaptosuccinic acid, and mixtures thereof.

DETD Within some embodiments, the inventive compositions described herein

are reacted with an isocyanate compound to produce a polythiourethane

composition. The isocyanate may be any isocyanates capable of reacting

with the ***thiol*** esters, hydroxy ***thiol*** esters, and a

cross-linked ***thiol*** esters described herein to form a polyurethane composition. Generally, the isocyanate compound has

at least two isocyanate groups.

DETD In order to quantitatively measure the ***thiol*** sulfur, the

thiol sulfur analyses were conducted using silver nitrate

titration in accordance with ASTM D3227, with the following modifications designed to minimize probe fouling by silver salts:

the samples were diluted in a known mass of tetrahydrofuran. The

silver nitrate concentration was 0.01 N standardized against potassium iodide.

DETD ***Thiol*** sulfur was analyzed by three different tests.

The first test used was the modified ASTM D3227, which resulted in a

thiol sulfur measurement of 4.64%. The second test used to measure the ***thiol*** sulfur was SLP-1204, which is a test developed by

Chevron Phillips Chemical Company LLP. By using the SLP-1204 test, the

resulting
 sulfur was ***thiol*** sulfur measurement was 4.28%. Lastly, the total sulfur was measured by combustion analysis, which resulted in a total sulfur measurement of 4.27%.

DETD Vegetable oil (42 kg) was charged to a 100-gallon holding vessel. The vessel was purged with nitrogen and returned to atmospheric pressure. Hydrogen sulfide (174 kg) was charged to the holding vessel. The vessel temperature was controlled from 25-30.degree. C. while the pressure was typically maintained between 380-400 psig. The reactants were continuously rolled from the holding tank through a stainless steel tubular photochemical reactor containing a 7.5 KW Hanovia medium pressure mercury lamp contained within a quartz tube. Reactor temperature, pressure, and composition were monitored over the course of the reaction. The reaction time was dependent upon reaching a desired composition of ***thiol*** sulfur. Upon completion, the unreacted hydrogen sulfide was slowly vented from the system. Residual H.sub.2S was removed at 100.degree. C. and reduced pressure while passing nitrogen through a nitrogen sparge tube. The product was drained from the bottom of the reactor into a clean drum. The ***thiol*** sulfur measurements were 11.0% when using the modified ASTM D3227, 8.74% when using SLP-1204, and the total sulfur was 11.21% when using combustion analysis (total sulfur).

DETD The resulting mercaptanized soybean oil was subjected to nitrogen sparging under reduced pressure at 100.degree. C. for a period of 4 hours to remove any residual hydrogen sulfide. The ***thiol*** sulfur measurements were 13.0% when using the modified ASTM D3227, 9.82% when using SLP-1204, and 11.69% when using combustion analysis.

DETD Table 1 provides the properties of the mercaptanized soybean oil produced in examples 1-3.

TABLE 1

Mercaptanized Soybean Oil Product Properties

C.dbd.C	Cyclic Sulfide to ***Thiol*** Sulfur.sup..dagger. Group		
	to ***Thiol*** (wt %)	groups Molar Ratio	Molar Ratio
Example			
1	4.28	0.02	2.79
2	11.0	0.03	0.26
3	13.0	0.03	0.51

.sup..dagger. ***Thiol*** sulfur content determined by the modified ASTM D3227

DETD Soybean oil was charged to a 1000 gallon stirred reactor. Hydrogen sulfide was then charged to the reactor. After the hydrogen sulfide was charged to the reactor, the stirrers and the UV lamps were turned on and the reaction allowed to build temperature and pressure as the reaction proceed. The reaction was continued until a minimum ***thiol*** sulfur content of 8 weight percent was achieved. After reaction was completion, the excess hydrogen sulfide was flashed from the reactor.

For runs 2-5, the mercaptanized soybean oil product underwent an additional hydrogen sulfide stripping step comprising stripping hydrogen sulfide from the product under vacuum, 50 mm Hg, at 250.degree. F. (only true for runs 2-5).

DETD Table 3 provides the details of the analysis of the mercaptanized soybean oil producing in the five 1000 gallon reactor runs.

TABLE 3

1000 gallon reactor Mercaptanized Soybean Oil Product Properties				
Run Number	***Thiol*** Containing Sulfur.sup..dagger. Group		Cyclic Sulfide to Side Chain C.dbd.C	
	Thiol (wt %)	Groups Molar Ratio	groups Molar Ratio	groups (%)
1	9.3	--	--	71.6
2	9.6	0.04	0.48	72.3
3	9.2	0.03	0.59	69.1
4	9.3	0.03	0.62	71.6
5	10.1	0.03	0.54	72.3

.sup..dagger. ***Thiol*** sulfur content determined by Raman spectroscopy

Mercaptanized Castor Bean Oil

DETD The analytical properties of the two mercaptanized castor oil products are provide in Table 4.

TABLE 4

Mercaptanized Castor Oil Product Properties				
Example	***Thiol*** Containing Sulfur.sup..dagger. Group		Side Chain C.dbd.C to groups	
	Thiol (wt %)	Groups Molar Ratio	***Thiol*** (%)	groups
1	6.4	0.52	64.1	

.sup..dagger. ***Thiol*** sulfur content determined by Raman spectroscopy

Mercaptohydroxy Soybean Oil Synthetic Procedure

DETD Epoxidized Soybean Oil (700 g, .about.0.7 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 4.7 g, 30.5 mmol) were charged to a 1-L Hastelloy C autoclave reactor that was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 132.0 g, 3.87 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 8 hrs, during which time the reactor pressure decreased from a maximum of 351 psig to 219 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<5 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content

of 7.53 wt. %, 2.5 SH/molecule, or 2.35 meq SH/g. Combustion analysis indicated

C, 64.37%; H, 10.20%; N, <0.15%; and S, 9.51%.

DETD Epoxidized Soybean Oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor, and the vessel was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 97.degree. C. with stirring for 14 hrs, during which time the reactor pressure decreased from a maximum of 509 psig to 229 psig. The stirrer was stopped and while still warm (90-95.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<5 mmHg) at 130-140.degree. C. for 16 hrs to remove residual

H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content of 4.14

wt. %, 1.4 SH/molecule, or 1.29 meq SH/g. Combustion analysis indicated C, 65.18%; H, 10.17%; N, <0.15%; and S, 7.80%.

DETD Epoxidized Soybean Oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor, and the vessel was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 10 hrs, during which time the reactor pressure decreased from a maximum of 578 psig to 489 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration with modified ASTM D3227) content of 8.28 wt. %, 2.8 SH/molecule, or 2.58 meq SH/g. Combustion analysis indicated C, 65.24%; H, 9.52%; N, 0.18%; and S, 9.53%.

DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor that was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 12 hrs, during which time the reactor pressure decreased from a maximum of 587 psig to 498 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content of 8.24 wt. %, 2.8 SH/molecule, or 2.57 meq SH/g. Combustion analysis indicated

C, 63.39%; H, 10.01%; N, <0.15%; and S, 8.76%.

DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor, and the vessel was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 8 hrs, during which time the reactor pressure decreased from a maximum of 606 psig to 537 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content of 7.34 wt. %, 2.5 SH/molecule, or 2.29 meq SH/g. Combustion analysis indicated C, 64.47%; H, 10.18%; N, <0.15%; and S, 8.40%.

DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor that was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 6 hrs, during which time the reactor pressure decreased from a maximum of 586 psig to 556 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content of 5.93 wt. %, 2.0 SH/molecule, or 1.85 meq SH/g. Combustion analysis indicated C, 65.26%; H, 10.19%; N, <0.15%; and S, 8.43%.

DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and

1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor, and the vessel was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 4 hrs, during which time the reactor pressure decreased from a maximum of 595 psig to 554 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content of 5.36 wt. %, 1.8 SH/molecule, or 1.67 meq SH/g. Combustion analysis indicated C, 65.67%; H, 10.17%; N, 0.34%; and S, 9.84%.

DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor that was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 4 hrs, during which time the reactor pressure decreased from a maximum of 577 psig to 519 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration with AgNO.sub.3) content of 5.85 wt. %, 2.0 SH/molecule, or 1.82 meq SH/g. Combustion analysis indicated C, 65.09%; H, 10.15%; N, 0.35%; and S, 10.63%.

DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged

to a 1-L Hastelloy C autoclave reactor, and the vessel was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 2 hrs, during which time the reactor pressure decreased from a maximum of 577 psig to 508 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<5 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content of 5.07 wt. %, 1.7 SH/molecule, or 1.58 meq SH/g. Combustion analysis indicated C, 63.96%; H, 10.01%; N, 0.35%; and S, 11.22%. DETD Table 5 provides the properties of the mercaptohydroxy soybean oil samples produced in Examples 1-10.

TABLE 5

Ex- ***Epoxide*** ample	Time (hrs)	Reac- tion Temp	Reac- tion Temp	***Mercaptan***		***Epoxides***	
		:SH	:SH	Sulfur	SH per	left per	groups
molecule.sup.3	Molar						
Ratio							
1	0	N/A	N/A	0	4.3	--	
2	8	85	7.53	2.5	1.8	0.72	
3	14	97	4.14	1.4	2.9	2.07	
4	10	85	8.28	2.8	1.5	0.54	
5	12	85	8.24	2.8	1.5	0.54	
6	8	85	7.34	2.5	1.8	0.72	
7	6	85	5.93	2.0	2.3	1.15	
8	4	85	5.36	1.8	2.5	1.40	
9	4	85	5.85	2.0	2.3	1.15	
10	2	85	5.07	1.7	2.6	1.529	

.sup.1Thiol sulfur was determined by silver nitrate oxidation using ASTM D 3227

.sup.2Determined by wt. % ***thiol*** sulfur

.sup.3Determined by subtracting the SH/molecule from the starting material

epoxide content

DETD Epoxidized soybean oil and the catalyst were charged to a 1-L

Hastelloy

C autoclave reactor, and the vessel was pressure tested to 1000 psig.

Hydrogen sulfide was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at temperature a set period of time with stirring for 12 hrs. During the reaction time the reactor pressure usually decreased. At

the end of the reaction time, the stirrer was stopped and excess H.sub.2S was slowly vented while the reaction mixture was warm to

a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained. The reaction product was

N.sub.2 sparged under vacuum (<50 mmHg) at 100.degree. C. for 16 hrs to remove residual H.sub.2S. Table 6 provides the reaction conditions used

to produce the mercaptohydroxy soybean oils for several runs and the

thiol sulfur content of the mercaptohydroxy soybean oils produced.

TABLE 6

Mercaptohydroxy Soybean Oil Production Runs

Run	Epoxidized Soybean Oil Temperature (g)	Catalyst Time (g)	H.sub.2S ***Thiol*** (g)	H.sub.2S: Sulfur.sup.a Molar Ratio (.degree. C.)	***Epoxide*** Sulfur.sup.a (.degree. C.)
556-41.sup..dagger.	249.6		1.950	214.0	5.86
	728	5.69			64
556-53.sup..dagger.	250.0		2.000	213.0	5.81
	370	9.04			100
556-47.sup..dagger.	250.5		1.050	213.0	5.81
	720	10.47			101
407-81D.sup..dagger.	500.0		4.200	255.0	3.49
	480	7.53			85
407-86.sup..dagger.	600.0		5.000	204.0	2.07
	600	8.28			85
556-79.sup..dagger-dbl.	250.0		2.600	214.0	5.83
	720	6.68			100
556-80.sup..dagger-dbl.	251.0		5.000	214.0	5.81
	720	9.51			100

.sup..dagger.Catalyst was DBU

.sup..dagger-dbl.catalyst was triethylamine (TEA)

.sup.aThiol sulfur measured by silver nitrate titration using modified ASTM D

3227

DETD Run number 407-86 was subjected to the sodium methoxide methanolysis

procedure and subsequently analyzed by GC/MS. The GS/MS analysis indicated that the product had ***epoxide*** group to

thiol group molar ratio of approximately 0.14. The methanolysis data also indicated that an average of 80.4 percent of the product mercaptohydroxy soybean oil contained sulfur.

DETD Mercaptanized soybean oil (900.1 g; 10.92 wt. % ***thiol*** sulfur,) was charged to a three necked flask along with elemental sulfur pellets (9.6 g). The reaction mixture was heated to 120.degree. C. until sulfur dissolved and then cooled to 99.degree. C. Tributylamine (4.8 g) was charged to the reaction mixture with an addition funnel drop wise. The reaction mixture was mixed at 90.degree. C. for 2 hrs. H.sub.2S evolution was observed. The reaction product (904.8 g) was sparged with N.sub.2 under vacuum at 110.degree. C. for 4 hrs to remove residual H.sub.2S. The final product was a light yellow oil with a ***thiol*** sulfur of 6.33 wt. % (by modified ASTM D3227). The elemental combustion analysis was 70.19%; C, 10.37%; H, and 11.21%; S.

DETD Mercaptanized soybean oil (900.0 g; 10.92 wt. % ***thiol*** sulfur,) was charged to a three necked flask along with elemental sulfur pellets (36.0 g). The reaction mixture was heated to 120.degree. C. until sulfur dissolved and then cooled to 100.degree. C. Tributylamine (4.8 g) was charged to the reaction mixture with an addition funnel drop wise. The reaction mixture was mixed at 90.degree. C. for 36 hrs. H.sub.2S evolution was observed. The reaction product (825.6 g) was sparged with N.sub.2 under vacuum at 90.degree. C. for 36 hrs to remove residual H.sub.2S. The reaction product was then sparged with N.sub.2 under vacuum at 110.degree. C. for 3 hrs to remove residual H.sub.2S. The final product was a light yellow oil with a ***thiol*** sulfur of 2.36 wt. % (by modified ASTM D3227). The elemental combustion analysis was 68.90%; C, 11.07%; H, and 12.25%; S.

DETD Mercaptanized soybean oil (900.1 g; 10.92 wt. % ***thiol*** sulfur,) was charged to a three necked flask along with elemental sulfur pellets (18.0 g). The reaction mixture was heated to 125.degree. C. until sulfur dissolved and then cooled to 101.degree. C. Tributylamine (4.8 g) was charged to the reaction mixture with an addition funnel drop wise. The reaction mixture was mixed at 90.degree. C. for 2 hrs.

H.sub.2S evolution was observed. The reaction product (901.5 g) was sparged with N.sub.2 under vacuum at 110.degree. C. for 4 hrs to remove residual H.sub.2S. The final product was a light yellow oil with a ****thiol*** sulfur of 4.9 wt. % (by modified ASTM D3227). The elemental combustion analysis was 69.58% C, 11.25% H, and 11.31% S.

DETD Mercaptanized soybean oil (900.2 g; 10.92 wt. % ****thiol*** sulfur,) was charged to a three necked flask along with elemental sulfur pellets (45.0 g). The reaction mixture was heated to 125.degree. C. until sulfur dissolved and then cooled to 100.degree. C.

Tributylamine (4.8 g) was charged to the reaction mixture with an addition funnel drop wise. The reaction mixture was mixed at 90.degree. C. for 2 hrs. H.sub.2S evolution was observed. The reaction product (915.0 g) was sparged with N.sub.2 under vacuum at 110.degree. C. for 4 hrs to remove residual H.sub.2S. The final product was a light yellow oil with a ****thiol*** sulfur of 1.41 wt. % (by modified ASTM D3227).

The elemental combustion analysis was 68.35% C, 10.98% H, and 13.28% S.

DETD Numerous polythiourethane compositions were prepared by reacting a ****thiol*** ester composition with a diisocyanate in the presence of a catalyst by using the processes described herein for preparing such polythiourethane compositions. The compositions were produced using the different variables of feedstocks, diisocyanates, stoichiometry, and catalysts shown in Table 8. Once every combination of variable was used, over 1200 compositions were produced. Each of the feedstocks were reacted with each of the diisocyanates at each of the stoichiometries with each of the catalysts listed to produce the 1200+ compositions. The stoichiometry was based upon a ****thiol*** ester composition (MSO, MHSO, CMSO, MCO) active hydrogen (****thiol*** and hydroxyl group) to diisocyanate equivalent ratio. For example, castor oil was reacted with toluene diisocyanate at a stoichiometric value of 1.25 while using Jeffol.RTM. A-480 as the catalyst. As another example, a ****thiol*** ester composition was reacted with methane diisocyanate at a stoichiometric value of 0.9 while using the DABCO catalyst.

DETD In the first MCO polythiourethane example, MCO was weighed into a

polyethylene beaker. To the MCO agent was added Luprinate at a
thiol to isocyanate mole ratio of 0.95. To this
reaction mixture
was added dibutyl tin dilaurate (DBTDL) at a weight percent of
0.125
based upon the total weight of the ingredients. The three-
component
reaction mixture was then manually stirred with a wooden Popsicle
stick.
The entire pre-polymer mixture was then poured into a mold for
curing
and cured using curing profile B. After the curing time was
complete it
was determined that the preparation produced a polythiourethane
polymer.
DETD In the second MCO polythiourethane example, MCO was weighed into
a
polyethylene beaker. To the MCO agent was added Luprinate M20S at
a
thiol to isocyanate mole ratio of 1.00. To this
reaction mixture
was added dibutyl tin dilaurate (DBTDL) at a weight percent of
0.125
based upon the total weight of the ingredients. The three-
component
reaction mixture was then manually stirred with a wooden Popsicle
stick.
The entire pre-polymer mixture was then poured into a mold for
curing
and cured using curing profile B. After the curing time was
complete it
was determined that the preparation produced a polythiourethane
polymer.
DETD In the polythiourethane compositions, the feedstock
thiol
ester compositions that were used included MSO (mercaptanized
soybean
oil), MHSO (mercaptohydroxy soybean oil), CMSO (cross-linked
mercaptanized soybean oil), castor oil, and MCO (mercaptanized
caster
oil). The diisocyanates that were used to produce these
compositions
included MDI (4,4'-methylenebis(phenyl) diisocyanate), HMDI
(4,4'-methylenebis(cyclohexyl) diisocyanate, which is also known
as
hydrogenated MDI), TDI (tolylene 2,4-diisocyanate), HDI
(1,6-diisocyanatohehexane, which is also known as hexamethylene
diisocyanate), and Luprinate.TM. M20S (which is an oligomerized
form of
MDI and is also referred to as polymeric MDI that is produced by
BASF
Corporation). The catalysts that were used included DABCO
(diazabicyclooctane-di-tertiary amine), DBTDL (dibutyl tin
dilaurate-organometallic catalyst), Jeffol.RTM. A-480 (which is a
tertiary amine polyol produced by Huntsman Based Chemicals), and
BDMA
(benzylidimethylamine).
DETD B1: Mercaptanized soybean oil (an example of MVO discussed
above)--Polymercaptan 358, available from Chevron Phillips
Chemical Co.;

8.65% ***thiol*** sulfur; 370 equivalent weight; viscosity of 510.6 cSt @ 21.degree. C.;

DETD B2: Mercapto-hydroxy soybean oil (an examples of MHVO discussed above)--A mercapto-hydroxy soybean oil made by the free radical addition of hydrogen sulfide to epoxidized soybean oil; the mercapto and hydroxy functionalities are equal; 8.335% ***thiol*** sulfur; equivalent weight 192 (including both mercapto and hydroxy functionalities);

DETD B3: Sulfur cross-linked mercaptanized soybean oil (an example of CMVO discussed above)--A sulfur cross-linked mercaptanized soybean oil made by the addition of elemental sulfur to mercaptanized soybean oil; ***thiol*** sulfur content 6.33%; equivalent weight 506;

DETD B4: Sulfur cross-linked mercaptanized soybean oil (an example of CMVO discussed above)--A sulfur cross-linked mercaptanized soybean oil made by the addition of elemental sulfur to mercaptanized soybean oil; ***thiol*** sulfur content 7.64%; equivalent weight 419; cross-linkcross-link

DETD F2: Amine catalyst: 1,8-Diazabicyclo[5,4,0]undec-7-ene (DBU), CAS#

DETD ***6674-22-2*** .

DETD Analysis of the ***Thiol*** Containing Esters, Hydroxy ***Thiol*** Containing Esters and Cross-Linked ***Thiol*** Containing Ester

DETD Particular aspects of the ***thiol*** containing esters, hydroxy

ester, ***thiol*** containing esters, cross-linked ***thiol***

were unsaturated esters and epoxidized unsaturated esters are measured particular analytical techniques. ***Thiol*** sulfur values

were obtained using a silver nitrate titration as described in ASTM D3227 or by Raman spectroscopy. Carbon-carbon double bond to ***thiol*** group molar ratio, cyclic sulfide to ***thiol*** group molar ratios

were determined by .sup.13C NMR and/or GC analysis of the ***thiol*** containing ester or hydroxy ***thiol*** containing ester side chains.

DETD ***Thiol*** Sulfur Content by Raman Spectroscopy

DETD ***Thiol*** sulfur content was measured by both silver nitrate titration, ASTM D3227, and/or Raman spectroscopy. The Raman spectroscopy method is practiced by measuring the Raman spectra of the ***thiol*** containing ester, hydroxy ***thiol*** containing ester, cross-linked ***thiol*** ester and comparing the spectra to calibration standards containing know ***thiol*** compounds having know amounts of ***thiol*** groups. Generally, the calibration standard ***thiol***

compound has a similar structure to the ***thiol*** containing esters analyzed.

DETD The ***thiol*** containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester ***thiol*** content were determined by comparing the Raman spectra of the ***thiol*** containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester to calibration standards prepared from mercaptanized methyl oleate diluted in soybean oil to known ***thiol*** sulfur contents. ***Thiol*** sulfur calibration standards were prepared using standards using various known concentration of mercaptanized methyl oleate diluted in soybean oil.

DETD Raman spectra of the calibration standards and the ***thiol*** containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester were measured using a Kaiser Hololab 5000 Process Raman spectrometer, using a 785 nm laser.

Thiol containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester samples and the ***thiol*** sulfur calibration standard Raman spectra were obtained by collecting four 10 second scans which were then processed using Holoreact software.

Thiol sulfur values for the ***thiol*** containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester were then calculated using the ratio of the peak area values of the ***thiol*** SH peak (center: 2575 cm⁻¹; area 2500-2650 cm⁻¹), and the C.dbd.O peak (center--1745 cm⁻¹; area--1700-1800 cm⁻¹) and comparing them to the peak area values for the calibration standards and interpolating the containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester ***thiol*** sulfur contents. Repeatability of the ***thiol*** sulfur values as measured by Raman spectroscopy have been shown to have a standard deviation of 0.05-0.1 and a % RSD of 0.6-1.5 using 5 samples having a % ***thiol*** sulfur content ranging from 3.1-10.6 weight percent as measured over a two month period.

DETD The Raman spectroscopy technique for determining the ***thiol*** sulfur content of a ***thiol*** containing ester, hydroxy ***thiol*** containing ester, and a cross-linked ***thiol***

containing ester has been illustrated using a ***thiol*** containing ester produced from soybean oil. However, one skilled in the art may adapt and apply the Raman spectroscopy technique for determining the ***thiol*** sulfur content of other ***thiol*** containing esters, hydroxy ***thiol*** containing esters, and a cross-linked ***thiol*** containing esters described herein.

DETD C.dbd.C to ***Thiol*** Group and Cyclic Sulfide Group to ***Thiol*** Group Molar Ratios by .sup.13C NMR

DETD Carbon-carbon double bond to ***thiol*** group molar ratio and cyclic sulfide group to ***thiol*** group molar ratios were determined by .sup.13C NMR. ***Thiol*** containing ester .sup.13C NMR spectra were obtained on a Varian Mercury INOVA400 NMR, a Varian Mercury Plus 300 NMR, or equivalent spectrometer (75.5 MHz .sup.13C NMR). Peak areas were determined for the cyclic sulfide carbon atoms, ***thiol*** group HS--C carbon atoms and carbon-carbon double bonds carbon atoms using the .sup.13C NMR regions indicated in the table below:

Functional Group	.sup.13C NMR Region	Number of Carbon Atoms/Group
Cyclic Sulfide Carbon Atoms	49-49.5 ppm	2
HS--C Carbon Atoms	40-41.5 ppm	1
C.dbd.C Carbon Atoms	120-140 ppm	2
DETD The ***thiol*** containing ester cyclic sulfide to ***thiol*** group molar ratio were calculated by dividing the cyclic sulfide carbon atoms .sup.13C NMR peak area by 2 (to account for the 2 carbon atoms per cyclic sulfide group) and dividing the resultant number by the ***thiol*** group HS--C carbon atoms .sup.13C NMR peak area.		
The ***thiol*** containing ester carbon-carbon double bond to ***thiol*** group molar ratio were calculated by dividing the C.dbd.C carbon atoms .sup.13C NMR peak area by 2 (to account for the 2 carbon atoms per carbon-carbon double bond) and dividing the result by the ***thiol*** group HS--C carbon atoms .sup.13C NMR peak area		
Offset sample .sup.13C NMR's for soybean oil and a ***thiol*** containing ester produced from soybean oil using the disclosed process is provided as FIG. 1.		
DETD The NMR technique for analyzing the unsaturated ester and the		

thiol containing ester produced from an unsaturated ester have been illustrated using .sup.13C NMR on soybean oil the ***thiol*** containing ester produced from soybean oil. However, one skilled in the art may adapt and apply either the .sup.13C NMR or .sup.1H NMR technique to analyze the unsaturated esters and ***thiol*** containing ester produced from the unsaturated ester described herein.

DETD ***Epoxide*** Group to ***Thiol*** Group Molar Ratios by .sup.13C or .sup.1H NMR

DETD The ***epoxide*** group to ***thiol*** group molar ratios were determined using .sup.1H or .sup.13C NMR. Hydroxy ***thiol*** containing ester .sup.1H or .sup.13C NMR spectra were obtained on a Varian Mercury INOVA400 NMR, a Varian Mercury Plus 300 NMR, or equivalent spectrometer (300 MHz .sup.1H NMR--75.5 MHz .sup.13C NMR). Peak areas were determined for the ***epoxide*** group and sulfide group using the .sup.13C and or .sup.1H regions indicated in the table below:

Functional Group	.sup.1H NMR Region	.sup.13C NMR Region	Number of Carbon Atoms/Group	Number of Hydrogen Atoms/Group
2 Group Carbon Atoms HS--C Carbon Atoms DETD The hydroxy group to	***Epoxide*** 3.2-4	2.75-3.2 ppm ppm 40-41.5	53.6-56.6 ppm ppm 1	2 1
(to group the to peak DETD	***thiol*** group molar ratio were calculated by dividing the ***epoxide*** group carbon atoms .sup.1H NMR peak area by 2 account for the 2 hydrogen atoms attached to the ***epoxide*** carbon atoms) and dividing the result number by the ***thiol*** group HS--C carbon atom hydrogens 1C NMR peak area. Similarly, hydroxy ***thiol*** containing ester ***epoxide*** group ***thiol*** group molar ratio were calculated using 13H NMR areas. The average number of ***epoxide*** group per epoxidized unsaturated ester molecule can be determined utilizing similar			

methods
 utilizing either the carbonyl group carbon atom or the C--O ester
 group carbon atoms .sup.13C NMR peak areas in conjunction with the
 epoxide group .sup.13C NMR peak area. Sample .sup.1H
 NMR's epoxidized soybean oil and a ***thiol*** containing ester
 produced from epoxidized soybean oil 1 are provided in FIG. 2.
 DETD The NMR technique for analyzing the epoxidized unsaturated ester
 and the ***thiol*** containing ester produced from an epoxidized
 unsaturated ester (a hydroxy ***thiol*** containing ester)
 has been illustrated using .sup.1H NMR on epoxidized soybean oil the
 thiol containing ester produced from epoxidized soybean
 oil. However, one skilled in the art may adapt and apply either the
 .sup.1H NMR or .sup.13C NMR technique to analyze the epoxidized
 unsaturated esters and ***thiol*** containing ester produced from the
 epoxidized unsaturated ester described herein.
 DETD Analysis of Unsaturated Esters, Epoxidized Unsaturated Esters,
 Thiol Containing Esters, and Hydroxy ***Thiol***
 Containing Esters by Methanolysis
 DETD Many properties of the unsaturated esters, epoxidized
 unsaturated esters, ***thiol*** containing esters, and hydroxy
 thiol containing ester were and/or can be determined by converting the
 complex ester molecules into their component polyols and carboxylic acid
 methyl esters. The converted esters are then analyzed by gas
 chromatography (GC) and/or gas chromatography/mass spectrometry (GCMS) to
 determine the composition of the complex ester side chains. Properties that are
 or can be determined by the methanolysis followed by GC or GC/MS of the
 that carboxylic acid methyl esters include the number of side chain
 group contain ***thiol*** groups, the percent of ***thiol***
 ester sulfur, the number of (or average number) of double bonds per
 molecule, the molecular weight distribution (or average molecular
 weight) of the ester side chains, the number of (or average
 number of) ***epoxide*** groups per ester molecule, the cyclic sulfide
 to ***thiol*** group molar ratio, the carbon-carbon double bond
 to ***thiol*** group molar ratio, and the ***epoxide***
 group to ***thiol*** group molar ratio, among others.
 DETD Depending upon the material being subjected to the methanolysis

procedure, there are two methanolysis procedures that were practiced upon the unsaturated ester, epoxidized esters, ****thiol*** containing ester, and hydroxy ****thiol*** containing esters described within the experimental section.

DETD Unsaturated esters and ****thiol*** containing ester produced from unsaturated ester were subjected to a hydrogen chloride based methanolysis procedure. In the hydrogen chloride methanolysis procedure, a 50 to 100 mg sample of the ****thiol*** containing ester is contacted with 3 mL of 3 N methanolic HCl and reacted for 2 hours

a 50.degree. C. The solution is then allowed to cool and the neutralized with a dilute sodium bicarbonate solution. The solution's organic components are then extracted with ethyl ether and analyzed by GC and/or GC/MS. Additional details for the methanolic hydrogen chloride methanolysis procedure may be found in the product specification sheet for methanolic HCl, 0.5 N and 3 N as supplied by Supelco.

DETD Epoxidized unsaturated esters and hydroxy ****thiol*** containing esters produced from epoxidized unsaturated esters were subjected to a sodium methoxide based methanolysis procedure. The sodium methoxide methanolysis procedure was based upon the procedure disclosed in U.S. Pat. No. 3,991,089. In the sodium methoxide methanolysis procedure, approximately 1 g of the ester was placed in a 50 mL vial with 5.0 mL 25% sodium methoxide in methanol, and 10 mL methanol. The mixture was shaken for approximately 1 hour at room temperature, during which time the solution became one phase. The mixture was then poured into 25 mL of distilled water. Diethyl ether, 25 mL, was added to the solution and the mixture was acidified with 0.5 N HCL to a pH of approximately 5. The organic layer was separated from the aqueous layer using a separatory funnel. The organic layer was washed successively with distilled water (15 mL) and brine solution (15 mL) and then dried over magnesium sulfate. The magnesium sulfate was separated from the organic solution by filtration and the solvent removed by rotary evaporation.

DETD FIG. 3 provides a GC/MS trace of a mercaptanized soybean oil subjected to the methanolysis procedure and analyzed by GC/MS using a HP-5 30 m.times.0.32 mm id.times.0.25 .mu.m film thickness GC Column.

Table 11 provides the GC/MS trace peak assignments.

TABLE 11

GC/MS Data for Methanolysis of A ***Thiol*** Containing Ester
Produced from
Soybean Oil

GC Retention time Methyl Ester Carboxylic Acid Assignment

21.58	Methyl hexadecanoate
23.66	Methyl (C18 monoene)oate
23.74	Methyl (C18 monoene)oate
23.96	Methyl octadecanoate
26.46	Methyl (C18 Monoene monomercaptan)oate
26.59	Methyl (C18 Monoene monomercaptan)oate
26.66	Methyl (C18 Monoene monomercaptan)oate
26.80	Methyl (C18 monomercaptan)oate
27.31	Methyl (C18 cyclic sulfide)oate
27.44	Methyl (C18 cyclic sulfide)oate
29.04	Methyl (C18 dimercaptan)oate
29.15	Methyl (C18 dimercaptan)oate
29.37	Methyl (C18 monoene dimercaptan)oate
29.46	Methyl (C18 monoene dimercaptan)oate
30.50	Methyl (C18 di (cyclic sulfide))oate

Peaks at 29.37 or 29.46 could also contain Methyl (C18 cyclic sulfide monomercaptan)oate isomers as part of those peaks.

DETD FIG. 5 provides a GC/MS trace of an epoxidized soybean oil contacted

with hydrogen sulfide (a hydroxy ***thiol*** containing ester)

subjected to the methanolysis procedure and analyzed by GC/MS using a

HP-5 30 m.times.0.32 mm id.times.0.25 .mu.m film thickness GC Column.

Table 13 provides the GC/MS trace peak assignments.

TABLE 13

GC/MS Data for Methanolysis of a Hydroxy ***Thiol*** Containing Ester Produced from Epoxidized Soybean Oil

GC Retention time Methyl Ester Carboxylic Acid Assignment

16.09	Methyl hexadecanoate
17.68	Methyl octadecanoate
18.94	Methyl (C18 monoepoxide)oate
19.94	Methyl (C18 diepoxide)oate
20.14	Methyl (C18 diepoxide)oate
20.75	Methyl (C18 monohydroxy monothiol)oate
21-21.5	Methyl (C18 triepoxide)oate
22.82	Methyl (C18 dihydroxy dithiol)oate
22.90	Methyl (C18 monoepoxide monohydroxy monothiol)oate
27-27.5	Unidentified mixture of C18 sulfur containing methyl esters

DETD The methanolysis procedure and GC/MS procedure has been illustrate

using soybean oil, epoxidized soybean oil, and the ***thiol*** containing products derived from soybean oil and epoxidized soybean oil.

However, one skilled in the art can easily adapt the procedures to the

analysis of other unsaturated esters, epoxidized unsaturated ester, and the ***thiol*** containing products derived from the unsaturated esters and epoxidized unsaturated esters as described herein. DETD The polythiourethane produced from the ***thiol*** containing esters, hydroxy ***thiol*** containing esters, and cross linked ***thiol*** containing ester were analyzed using ASTM E1545-95A and E228-95 to provide the glass transition temperatures and the coefficients of thermal expansion. Shore hardness of the polythiourethanes were determined using ASTM D2240-02A. The polythiourethane were also subject to a subjective analysis classifying the polythiourethanes as hard, flexible, rubbery, rigid, tough, brittle, and other characteristics.

CLM What is claimed is:

1. A hydroxy ***thiol*** ester composition comprising hydroxy ***thiol*** ester molecules having an average of at least 1 ester groups per hydroxy ***thiol*** ester molecule and having an average of at least 1 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule.

CLM What is claimed is:

2. The composition of claim 1, wherein the hydroxy ***thiol*** ester molecules have an average ranging from 1.5 to 9 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule.

CLM What is claimed is:

3. The composition of claim 1, wherein the hydroxy ***thiol*** ester molecules have an average of greater than 2.5 weight percent ***thiol*** sulfur.

CLM What is claimed is:

4. The composition of claim 1, wherein the hydroxy ***thiol*** ester molecules have an average ranging from 8 to 10 weight percent ***thiol*** sulfur.

CLM What is claimed is:

5. The composition of claim 1, wherein the hydroxy ***thiol*** ester molecules have a molar ratio of ***epoxide*** groups to the .alpha.-hydroxy ***thiol*** groups of less than 2.

CLM What is claimed is:

6. The composition of claim 1, wherein greater than 40 percent of the hydroxy ***thiol*** ester molecule total side chains contain sulfur.

CLM What is claimed is:

7. The composition of claim 1, wherein the composition is substantially free of ***epoxide*** groups.

CLM What is claimed is:
8. A hydroxy ***thiol*** ester composition comprising hydroxy ***thiol*** ester molecules having an average of at least 1 ester groups per hydroxy ***thiol*** ester molecule, having an average of at least 1 ***thiol*** groups per hydroxy ***thiol*** ester molecule, and having an average of at least 1 alcohol groups per hydroxy ***thiol*** ester molecule.

CLM What is claimed is:
9. The composition of claim 8, wherein the hydroxy ***thiol*** ester molecules have an average ranging from 1.5 to 9 ***thiol*** groups per hydroxy ***thiol*** ester molecule.

CLM What is claimed is:
10. The composition of claim 8, wherein the hydroxy ***thiol*** ester molecules have an average ranging from 1.5 to 9 alcohol groups per hydroxy ***thiol*** ester molecule.

CLM What is claimed is:
11. The composition of claim 8, wherein the hydroxy ***thiol*** ester molecules have an average of greater than 2.5 weight percent ***thiol*** sulfur.

CLM What is claimed is:
12. The composition of claim 8, wherein the hydroxy ***thiol*** ester molecules have an average ranging from 8 to 10 weight percent ***thiol*** sulfur.

CLM What is claimed is:
13. The composition of claim 8, wherein the hydroxy ***thiol*** ester molecules have a molar ratio of ***epoxide*** groups to ***thiol*** groups of less than 2.

CLM What is claimed is:
14. The composition of claim 8, wherein greater than 40 percent of the hydroxy ***thiol*** ester molecule total side chains contain sulfur.

CLM What is claimed is:
15. The composition of claim 8, wherein the composition is substantially free of ***epoxide*** groups.

CLM What is claimed is:
16. A process for preparing a hydroxy ***thiol*** ester composition,

comprising the steps of: a) contacting hydrogen sulfide and an epoxidized unsaturated ester composition comprising epoxidized unsaturated esters having an average of at least 1 ester groups per epoxidized unsaturated ester molecule and having an average of at least 1 ***epoxide*** groups per epoxidized unsaturated ester molecule; and b) reacting the hydrogen sulfide and the epoxidized unsaturated esters to form the hydroxy ***thiol*** ester composition.

CLM What is claimed is:
19. The process of claim 16, wherein a molar ratio of the hydrogen sulfide to ***epoxide*** groups in the epoxidized unsaturated esters is greater than 1.

CLM What is claimed is:
21. The process of claim 16, wherein the hydroxy ***thiol*** ester composition comprises hydroxy ***thiol*** ester molecules having an average of greater than 2.5 weight percent ***thiol*** sulfur.

CLM What is claimed is:
22. The process of claim 16, wherein the hydroxy ***thiol*** ester composition comprises hydroxy ***thiol*** ester molecules having an average ranging from 8 to 10 weight percent ***thiol*** sulfur.

CLM What is claimed is:
23. The process of claim 16, wherein the hydroxy ***thiol*** ester composition comprises hydroxy ***thiol*** ester molecules having greater than 40 percent of the hydroxy ***thiol*** ester molecule total side chains contain sulfur.

CLM What is claimed is:
24. A process for preparing a hydroxy ***thiol*** ester composition comprising the steps of: a) contacting a polyol composition and a hydroxy ***thiol*** carboxylic acid composition; and b) reacting the polyol composition and the hydroxy ***thiol*** carboxylic acid composition to produce the hydroxy ***thiol*** ester composition comprising hydroxy ***thiol*** ester molecules having an average of at least 1 ester groups per hydroxy ***thiol*** ester molecule and having an average of at least 1 .alpha.-hydroxy ***thiol***

groups
per hydroxy ***thiol*** ester molecule.

IT 102-85-2, Tri-n-butylphosphite ***6674-22-2*** ,
1,8-Diazabicyclo[5.4.0]undec-7-ene
(activator; thiol ester compns. prepd. by reacting H2S with
unsatd. esters, such as soybean oil for manuf. monomers for prodn. of
polythiourethanes for fertilizers)

ACCESSION NUMBER: 2006:41458 USPATFULL <<LOGINID::20090306>>
TITLE: ***Thiol*** ester compositions and processes
for
making and using same

INVENTOR(S): Brown, Chad W., Bartlesville, OK, UNITED STATES
Refvik, Mitchell D., Bartlesville, OK, UNITED STATES

STATES Herron, Steven J., Kingwood, TX, UNITED STATES

PATENT ASSIGNEE(S): Chevron Phillips Chemical Company LP (U.S.
corporation)

	NUMBER	KIND	DATE
PATENT INFORMATION:	US 20060036110	A1	20060216
APPLICATION INFO.:	US 2005-60696	A1	20050217 (11)

	NUMBER	DATE
PRIORITY INFORMATION:	US 2004-545260P	20040217 (60)
	US 2004-561614P	20040413 (60)
	US 2004-561685P	20040413 (60)
	US 2004-561855P	20040413 (60)
DOCUMENT TYPE:	Utility	
FILE SEGMENT:	APPLICATION	
LEGAL REPRESENTATIVE:	Kimberly L. Brown, Chevron Phillips Chemical Company LP, 10001 Six Pines Drive, The Woodlands, TX, 77380, US	
NUMBER OF CLAIMS:	24	
EXEMPLARY CLAIM:	1	
NUMBER OF DRAWINGS:	14 Drawing Page(s)	
LINE COUNT:	6358	
CAS INDEXING IS AVAILABLE FOR THIS PATENT.		

L11 ANSWER 31 OF 85 USPATFULL on STN
SUMM The invention includes a process for the manufacturing of a
compound of
Formula I or its ester or salt thereof, ##STR2## wherein
Z.sup.1,
Z.sup.2, Z.sup.3, and Z.sup.4 are independently selected from the
group
consisting of hydrogen and alkyl, said alkyl optionally
substituted by
hydroxy, alkyl, alkenyl, acyl, nitro, amino, halo, carboxy and
cyano;
Z.sup.5 and Z.sup.6 are the same or different and independently
selected from
the group consisting of alkyl, alkenyl, and aryl all of which can
be
optionally substituted by hydroxy, alkyl, alkenyl, acyl, nitro,
amino,

halo, carboxy and cyano;
 Z.sup.5 and Z.sup.6 can come together to form a carbocyclic ring;
 M is selected from the group consisting of hydrogen, an optionally substituted
 unsaturated alkyl having from 1 to 10 carbon atoms, and an
 optionally substituted saturated alkyl having from 1 to 10 carbon atoms,
 said optionally substituted unsaturated alkyl and optionally substituted
 saturated alkyl optionally containing a polar or charged
 functionality;
 or M is selected from the group consisting of hydrogen, an optionally substituted unsaturated acyl having from 1 to 18 carbon atoms,
 and an optionally substituted saturated acyl having from 1 to 18 carbon atoms,
 said optionally substituted unsaturated acyl and optionally substituted
 saturated acyl optionally containing a polar or charged
 functionality;
 J is selected from the group consisting of an optionally substituted unsaturated alkyl having from 1 to 10 carbon atoms, and an
 optionally substituted saturated alkyl having from 1 to 10 carbon atoms,
 said optionally substituted unsaturated alkyl and optionally substituted
 saturated alkyl optionally containing a polar or charged
 functionality;
 or J is selected from the group consisting of an optionally substituted unsaturated acyl having from 1 to 18 carbon atoms and an
 optionally substituted saturated acyl having from 1 to 18 carbon atoms, said
 optionally substituted unsaturated acyl and optionally substituted
 saturated acyl optionally containing a polar or charged
 functionality;
 the process comprising:
 reacting a compound of Formula II, ##STR3## wherein Z.sup.1,
 Z.sup.2, Z.sup.3, Z.sup.4, Z.sup.5 and Z.sup.6 are as previously defined,
 with a compound of Formula III, ##STR4## wherein Y is R.sup.2 or NR.sup.2R.sup.5;
 R.sup.1, R.sup.2, R.sup.3 and R.sup.4 and R.sup.5 are independently selected
 from an optionally substituted C.sub.1-C.sub.10 alkyl or an
 optionally substituted C.sub.2-C.sub.10 alkenyl;
 R.sup.1 and R.sup.2 can optionally come together to form a ring;
 R.sup.3 and R.sup.4 can optionally come together to form a ring; and
 a compound selected from the group consisting of a saturated or unsaturated acyl halide, saturated or unsaturated carboxylic acid anhydride and a saturated or unsaturated activated carboxylic acid
 ester, all of which may optionally be substituted by one or more
 substituents selected from the group consisting of protected
 hydroxy,

alkyl, alkenyl, acyl, nitro, protected amino, amino, halo,
protected carboxy and cyano; or, a compound selected the group consisting
of a saturated or unsaturated alkyl halide, saturated or unsaturated
alkyl-O-sulfonyl alkyl, a saturated or unsaturated alkyl-O-
sulfonyl aryl, a saturated or unsaturated alkyl-O-acyl, and a saturated or
unsaturated ***epoxide***, all of which may optionally be
substituted by one or more substituents selected from the group
consisting of protected hydroxy, alkyl, alkenyl, acyl, nitro,
protected amino, halo, protected carboxy, ***epoxide*** and cyano; and,
separating and isolating the compound of Formula I.

SUMM The terms "alkyl" or "alk", alone or in combination, unless
otherwise specified, means a saturated straight or branched primary,
secondary, or tertiary hydrocarbon from 1 to 16 carbon atoms, including, but
not limited to methyl, ethyl, propyl, isopropyl, butyl, isobutyl, t-
butyl, and sec-butyl. The alkyl group may be optionally substituted
where possible with any moiety that does not otherwise interfere with
the reaction or that provides an improvement in the process,
including but not limited to halo, haloalkyl, hydroxyl, carboxyl, acyl, aryl,
acyloxy, amino, amido, carboxyl derivatives, alkylamino, dialkylamino,
arylamino, alkoxy, aryloxy, nitro, cyano, sulfonic acid, ***thiol***,
imine, sulfonyl, sulfanyl, sulfinyl, sulfamonyl, ester, carboxylic acid,
amide, phosphonyl, phosphinyl, phosphoryl, phosphine, thioester,
thioether, acid halide, anhydride, oxime, hydrozine, carbamate, phosphonic
acid, phosphonate, either unprotected, or protected as necessary, as
known to those skilled in the art.

SUMM The term "alkenyl", alone or in combination, means a non-cyclic
alkyl of 2 to 10 carbon atoms having one or more unsaturated carbon-
carbon bonds. The alkenyl group may be optionally substituted where
possible with any moiety that does not otherwise interfere with the
reaction or that provides an improvement in the process, including but not
limited to halo, haloalkyl, hydroxyl, carboxyl, acyl, aryl, acyloxy,
amino, amido, carboxyl derivatives, alkylamino, dialkylamino, arylamino,
alkoxy, aryloxy, nitro, cyano, sulfonic acid, ***thiol***,
imine,

amide, sulfonyl, sulfanyl, sulfinyl, sulfamonyl, ester, carboxylic acid,
thioether, phosphonyl, phosphinyl, phosphoryl, phosphine, thioester,
acid halide, anhydride, oxime, hydrozine, carbamate, phosphonic
acid, phosphonate, either unprotected, or protected as necessary, as
known to those skilled in the art.

SUMM The term "alkynyl", alone or in combination, means a non-cyclic
alkyl of 2 to 10 carbon atoms having one or more triple carbon-carbon
bonds, including but not limited to ethynyl and propynyl. The alkynyl
group may be optionally substituted where possible with any moiety that
does not otherwise interfere with the reaction or that provides an
improvement in the process, including but not limited to halo, haloalkyl,
hydroxyl, carboxyl, acyl, aryl, acyloxy, amino, amido, carboxyl
derivatives, alkylamino, dialkylamino, arylamino, alkoxy, aryloxy, nitro,
cyano, sulfonic acid, ***thiol***, imine, sulfonyl, sulfanyl,
sulfinyl, sulfamonyl, ester, carboxylic acid, amide, phosphonyl,
phosphinyl, phosphoryl, phosphine, thioester, thioether, acid halide,
anhydride, oxime, hydrozine, carbamate, phosphonic acid, phosphonate, either
unprotected, or protected as necessary, as known to those skilled
in the art.

SUMM The term "aryl", alone or in combination, means a carbocyclic
aromatic system containing one, two or three rings wherein such rings may
be attached together in a pendent manner or may be fused. The
"aryl" group can be optionally substituted where possible with one or more of
the moieties selected from the group consisting of alkyl, alkenyl,
alkynyl, heteroaryl, heterocyclic, carbocycle, alkoxy, oxo, aryloxy,
arylalkoxy, cycloalkyl, tetrazolyl, heteroaryloxy; heteroarylalkoxy,
carbohydrate, amino acid, amino acid esters, amino acid amides, alditol,
halogen, haloalkylthi, haloalkoxy, haloalkyl, hydroxyl, carboxyl, acyl,
acyloxy, amino, aminoalkyl, aminoacyl, amido, alkylamino, dialkylamino,
arylamino, nitro, cyano, ***thiol***, imide, sulfonic acid,
sulfate, sulfonate, sulfonyl, alkylsulfonyl, aminosulfonyl,
alkylsulfonylamino,

haloalkylsulfonyl, sulfanyl, sulfinyl, sulfamoyl, carboxylic ester, carboxylic acid, amide, phosphonyl, phosphinyl, phosphoryl, thioester, thioether, oxime, hydrazine, carbamate, phosphonic acid, phosphate, phosphonate, phosphinate, sulfonamido, carboxamido, hydroxamic acid, sulfonylimide or any other desired functional group that does not inhibit the pharmacological activity of this compound, either unprotected, or protected as necessary, as known to those skilled in the art. In addition, adjacent groups on an "aryl" ring may combine to form a 5- to 7-membered saturated or partially unsaturated carbocyclic, aryl, heteroaryl or heterocyclic ring, which in turn may be substituted as above.

SUMM The term "substituted", means that one or more hydrogen on the designated atom or substituent is replaced with a selection from the indicated group, provided that the designated atom's normal valency is not exceeded, and the that the substitution results in a stable compound. When a substituent is "oxo" (keto) (i.e., .dbd.O), then 2 hydrogens on the atom are replaced. If the term is used without an indicating group, an appropriate substituent known by those skilled in art may be substituted, including, but not limited to, hydroxyl, alkyl, alkenyl, acyl, nitro, protected amino, halo, protected carboxy, ***epoxide*** , and cyano.

SUMM The term "polar or charged functionality" means a polar or charged group attached in place of one or more hydrogen atoms. Non limiting examples include carboxy, hydroxy, amino, ***epoxide*** , etc.

SUMM The term " ***epoxide*** " means the radical ##STR7## wherein all R groups are independently selected from hydrogen, alkyl, aryl and arylalkyl wherein said alkyl, aryl and arylalkyl may optionally be substituted with a polar functionality.

DETD In a broad description, the invention encompasses the method of manufacturing a compound of Formula I or its ester or salt thereof, ##STR13## wherein Z.sup.1, Z.sup.2, Z.sup.3, and Z.sup.4 are independently selected from the group consisting of hydrogen and alkyl, said alkyl optionally substituted by hydroxy, alkyl, alkenyl, acyl,

nitro, amino, halo, carboxy and cyano;
 Z.sup.5 and Z.sup.6 are the same or different and independently
 selected from
 the group consisting of alkyl, alkenyl, and aryl all of which can
 be
 optionally substituted by hydroxy, alkyl, alkenyl, acyl, nitro,
 amino,
 halo, carboxy and cyano;
 Z.sup.5 and Z.sup.6 can come together to form a carbocyclic ring;
 M is selected from the group consisting of hydrogen, an optionally
 substituted
 unsaturated alkyl having from 1 to 10 carbon atoms, and an
 optionally
 substituted saturated alkyl having from 1 to 10 carbon atoms,
 said
 optionally substituted unsaturated alkyl and optionally
 substituted
 saturated alkyl optionally containing a polar or charged
 functionality;
 or M is selected from the group consisting of hydrogen, an optionally
 substituted unsaturated acyl having from 1 to 18 carbon atoms,
 and an
 optionally substituted saturated acyl having from 1 to 18 carbon
 atoms,
 said optionally substituted unsaturated acyl and optionally
 substituted
 saturated acyl optionally containing a polar or charged
 functionality;
 J is selected from the group consisting of an optionally substituted
 unsaturated alkyl having from 1 to 10 carbon atoms, and an
 optionally
 substituted saturated alkyl having from 1 to 10 carbon atoms,
 said
 optionally substituted unsaturated alkyl and optionally
 substituted
 saturated alkyl optionally containing a polar or charged
 functionality;
 or J is selected from the group consisting of an optionally substituted
 unsaturated acyl having from 1 to 18 carbon atoms and an
 optionally
 substituted saturated acyl having from 1 to 18 carbon atoms, said
 optionally substituted unsaturated acyl and optionally
 substituted
 saturated acyl optionally containing a polar or charged
 functionality;
 the process comprising:
 reacting a compound of Formula II, ##STR14## wherein Z.sup.1,
 Z.sup.2,
 Z.sup.3, Z.sup.4, Z.sup.5 and Z.sup.6 are as previously defined,
 with a
 compound of Formula III, ##STR15## wherein Y is R.sup.2 or
 NR.sup.2R.sup.5;
 R.sup.1, R.sup.2, R.sup.3 and R.sup.4 and R.sup.5 are independently
 selected
 from an optionally substituted C.sub.1-C.sub.10 alkyl or an
 optionally
 substituted C.sub.2-C.sub.10 alkenyl;
 R.sup.1 and R.sup.2 can optionally come together to form a ring;
 R.sup.3 and R.sup.4 can optionally come together to form a ring; and
 a

compound selected from the group consisting of a saturated or unsaturated acyl halide, saturated or unsaturated carboxylic acid anhydride and a saturated or unsaturated activated carboxylic acid

ester, all of which may optionally be substituted by one or more selected from the group consisting of protected hydroxy, alkyl, alkenyl, acyl, nitro, protected amino, amino, halo, protected carboxy and cyano;

or a compound selected the group consisting of a saturated or unsaturated alkyl halide, saturated or unsaturated alkyl-O-sulfonyl alkyl, a saturated or unsaturated alkyl-O-sulfonyl aryl, a saturated or unsaturated alkyl-O-acyl, and a saturated or unsaturated ***epoxide***

, all of which may optionally be substituted by one or more selected from the group consisting of protected hydroxy, alkyl, alkenyl, acyl, nitro, protected amino, halo, protected carboxy, ***epoxide*** and cyano; and separating and isolating said compound of Formula I.

DETD In a 2.sup.nd embodiment, the invention is represented by the process to manufacture a compound of Formula I or its ester or salt thereof,

##STR16## wherein Z.sup.1, Z.sup.2, Z.sup.3, and Z.sup.4 are independently selected from the group consisting of hydrogen and alkyl, said alkyl optionally substituted by hydroxy, alkyl, alkenyl, acyl, nitro, amino, halo, carboxy and cyano;

Z.sup.5 and Z.sup.6 are the same or different and independently selected from the group consisting of alkyl, alkenyl, and aryl all of which can be optionally substituted by hydroxy, alkyl, alkenyl, acyl, nitro, amino, halo, carboxy and cyano;

Z.sup.5 and Z.sup.6 can come together to form a carbocyclic ring;

M is selected from the group consisting of hydrogen, an optionally substituted unsaturated alkyl having from 1 to 10 carbon atoms, and an optionally substituted saturated alkyl having from 1 to 10 carbon atoms, said optionally substituted unsaturated alkyl and optionally substituted saturated alkyl optionally containing a polar or charged functionality;

and

J is selected from the group consisting of an optionally substituted unsaturated alkyl having from 1 to 10 carbon atoms, and an optionally substituted saturated alkyl having from 1 to 10 carbon atoms, said optionally substituted unsaturated alkyl and optionally substituted

saturated alkyl optionally containing a polar or charged
 functionality;
 the process comprising:
 reacting a compound of Formula II, ##STR17## wherein Z.sup.1,
 Z.sup.2,
 Z.sup.3, Z.sup.4, Z.sup.5 and Z.sup.6 are as previously defined,
 with a compound of Formula III, ##STR18## wherein Y is R.sup.2 or
 NR.sup.2R.sup.5;
 R.sup.1, R.sup.2, R.sup.3 and R.sup.4 and R.sup.5 are independently
 selected
 from an optionally substituted C.sub.1-C.sub.10 alkyl or an
 optionally
 substituted C.sub.2-C.sub.10 alkenyl;
 R.sup.1 and R.sup.2 can optionally come together to form a ring;
 R.sup.3 and R.sup.4 can optionally come together to form a ring; and
 a
 compound selected the group consisting of a saturated or
 unsaturated
 alkyl halide, saturated or unsaturated alkyl-O-sulfonyl alkyl, a
 saturated or unsaturated alkyl-O-sulfonyl aryl, a saturated or
 unsaturated alkyl-O-acyl, and a saturated or unsaturated
 epoxide
 , all of which may optionally be substituted by one or more
 selected
 from the group consisting of protected hydroxy, alkyl, alkenyl,
 acyl,
 nitro, protected amino, halo, protected carboxy, ***epoxide***
 and
 cyano; and separating and isolating said compound of Formula
 I.
 DETD In a 3.sup.rd embodiment, the invention is represented by the
 process
 to manufacture a compound of Formula IV or its ester or salt
 thereof,
 ##STR19## wherein J is selected from the group consisting of
 an
 optionally substituted unsaturated alkyl having from 1 to 10
 carbon
 atoms, and an optionally substituted saturated alkyl having from
 1 to 10
 carbon atoms, said optionally substituted unsaturated alkyl and
 optionally substituted saturated alkyl optionally containing a
 polar or
 charged functionality;
 the process comprising:
 reacting a compound of Formula V, ##STR20##
 with a compound of Formula III, ##STR21## wherein Y is R.sup.2 or
 NR.sup.2R.sup.5;
 R.sup.1, R.sup.2, R.sup.3 and R.sup.4 and R.sup.5 are independently
 selected
 from an optionally substituted C.sub.1-C.sub.10 alkyl or an
 optionally
 substituted C.sub.2-C.sub.10 alkenyl;
 R.sup.1 and R.sup.2 can optionally come together to form a ring;
 R.sup.3 and R.sup.4 can optionally come together to form a ring; and
 a
 compound selected from the group consisting of a saturated or
 unsaturated alkyl halide, saturated or unsaturated alkyl-O-
 sulfonyl
 alkyl, a saturated or unsaturated alkyl-O-sulfonyl aryl, a

saturated or unsaturated alkyl-O-acyl, and a saturated or unsaturated
 epoxide, all of which may optionally be substituted by one or more substituents selected from the group consisting of protected hydroxy, alkyl, alkenyl, acyl, nitro, protected amino, halo, protected carboxy, ***epoxide*** and cyano; and separating and isolating said compound of Formula IV.

CLM What is claimed is:
 10. A process for manufacturing a compound of Formula I or its ester or salt thereof, ##STR77## wherein Z.sup.1, Z.sup.2, Z.sup.3, and Z.sup.4 are independently selected from the group consisting of hydrogen and alkyl, said alkyl optionally substituted by hydroxy, alkyl, alkenyl, acyl, nitro, amino, halo, carboxy and cyano; Z.sup.5 and Z.sup.6 are the same or different and independently selected from the group consisting of alkyl, alkenyl, and aryl all of which can be optionally substituted by hydroxy, alkyl, alkenyl, acyl, nitro, amino, halo, carboxy and cyano; Z.sup.5 and Z.sup.6 can come together to form a carbocyclic ring; M is selected from the group consisting of hydrogen, an optionally substituted unsaturated alkyl having from 1 to 10 carbon atoms, and an optionally substituted saturated alkyl having from 1 to 10 carbon atoms, said optionally substituted unsaturated alkyl and optionally substituted saturated alkyl optionally containing a polar or charged functionality; and J is selected from the group consisting of an optionally substituted unsaturated alkyl having from 1 to 10 carbon atoms, and an optionally substituted saturated alkyl having from 1 to 10 carbon atoms, said optionally substituted unsaturated alkyl and optionally substituted saturated alkyl optionally containing a polar or charged functionality; the process comprising: reacting a compound of Formula II ##STR78## wherein Z.sup.1, Z.sup.2, Z.sup.3, Z.sup.4, Z.sup.5 and Z.sup.6 are as previously defined, with a compound of Formula III, ##STR79## wherein Y is R.sup.2 or NR.sup.2R.sup.5; R.sup.1, R.sup.2, R.sup.3 and R.sup.4 and R.sup.5 are independently selected from an optionally substituted C.sub.1-C.sub.10 alkyl or an optionally substituted C.sub.2-C.sub.10 alkenyl; R.sup.1 and R.sup.2

can optionally come together to form a ring; R.sup.3 and R.sup.4
the optionally come together to form a ring; and a compound selected
group consisting of a saturated or unsaturated alkyl halide,
saturated or unsaturated alkyl-O-sulfonyl alkyl, a saturated or unsaturated
alkyl-O-sulfonyl aryl, a saturated or unsaturated alkyl-O-acyl,
and a saturated or unsaturated ***epoxide***, all of which may
optionally be substituted by one or more substituents selected from the
group consisting of protected hydroxy, alkyl, alkenyl, acyl, nitro,
protected amino, halo, protected carboxy, ***epoxide*** and cyano; and
separating and isolating the compound of Formula I.

CLM What is claimed is:

11. The process of claim 10 to manufacture a compound of Formula
IV or its ester or salt thereof, ##STR80## wherein J is selected
from the group consisting of an optionally substituted unsaturated alkyl
having from 1 to 10 carbon atoms, and an optionally substituted
saturated alkyl having from 1 to 10 carbon atoms, said optionally substituted
unsaturated alkyl and optionally substituted saturated alkyl
optionally containing a polar or charged functionality; the process
comprising:
reacting a compound of Formula V ##STR81## with a compound
of Formula III, ##STR82## wherein Y is R.sup.2 or
NR.sup.2R.sup.5;
R.sup.1, R.sup.2, R.sup.3 and R.sup.4 and R.sup.5 are
independently selected from an optionally substituted C.sub.1-C.sub.10 alkyl or
an optionally substituted C.sub.2-C.sub.10 alkenyl; R.sup.1 and
R.sup.2 can optionally come together to form a ring; R.sup.3 and R.sup.4
can optionally come together to form a ring; and a compound selected
from the group consisting of a saturated or unsaturated alkyl halide,
saturated or unsaturated alkyl-O-sulfonyl alkyl, a saturated or
unsaturated alkyl-O-sulfonyl aryl, a saturated or unsaturated
alkyl-O-acyl, and a saturated or unsaturated ***epoxide***,
all of which may optionally be substituted by one or more substituents
selected from the group consisting of protected hydroxy, alkyl, alkenyl,
acyl, nitro, protected amino, halo, protected carboxy, ***epoxide***
and cyano; and separating and isolating the compound of Formula IV.
IT ***3001-72-7***, Dbn ***6674-22-2***, Dbu

(prepn. of esters of probucol and derivs. thereof using acid anhydrides in the presence of DBU or DBN)
 ACCESSION NUMBER: 2005:306544 USPATFULL <<LOGINID::20090306>>
 TITLE: Process of preparing esters and ethers of probucol and derivatives thereof
 INVENTOR(S): Weingarten, M. David, Cumming, GA, UNITED STATES

	NUMBER	KIND	DATE
PATENT INFORMATION:	US 20050267187	A1	20051201
	US 7294737	B2	20071113
APPLICATION INFO.:	US 2005-111194	A1	20050420 (11)

	NUMBER	DATE
PRIORITY INFORMATION:	US 2004-564267P	20040420 (60)
DOCUMENT TYPE:	Utility	
FILE SEGMENT:	APPLICATION	
LEGAL REPRESENTATIVE:	KING & SPALDING LLP, 191 PEACHTREE STREET, N.E., 45TH FLOOR, ATLANTA, GA, 30303-1763, US	
NUMBER OF CLAIMS:	11	
EXEMPLARY CLAIM:	1	
LINE COUNT:	1405	

CAS INDEXING IS AVAILABLE FOR THIS PATENT.

L11 ANSWER 36 OF 85 USPATFULL on STN
 TI ***thiol*** ester compositions and processes for making and using same
 AB ***thiol*** ester compositions, methods of making the ***thiol*** ester compositions, and methods of using the ***thiol*** ester compositions are provided. In some embodiments, the ***thiol*** ester compositions include ***thiol*** esters, hydroxy ***thiol*** esters and cross-linked ***thiol*** esters. The ***thiol*** ester composition can be used to produce cross-linked ***thiol*** esters, sulfonic acid-containing esters, sulfonate containing esters and thioacrylate containing esters. The ***thiol*** ester compositions can be used to produce polythiourethanes. The polythiourethanes can be used in fertilizers and fertilizer coatings.
 SUMM The invention relates to ***thiol*** containing ester compositions generally made from a reaction of unsaturated ester compositions and a material capable of forming a ***thiol*** group. The invention also relates to the processes for preparing such ***thiol*** containing compositions and uses for the ***thiol*** containing compositions.

SUMM The present invention advantageously provides ***thiol*** containing compositions and methods of making such compositions.

In addition to the compositions and methods of making such compositions, products that include such compositions are also provided.

SUMM As an embodiment of the present invention, a ***thiol*** ester composition is advantageously provided. In this embodiment, the ***thiol*** ester composition includes ***thiol*** ester molecules that have an average of at least 1.5 ester groups per ***thiol*** ester molecule. The ***thiol*** ester molecules also have an average of at least 1.5 ***thiol*** groups per ***thiol*** ester molecule. The ***thiol*** ester molecules also have a molar ratio of cyclic sulfides to ***thiol*** groups of less than 1.5.

SUMM In some aspects, the ***thiol*** ester molecules have a molar ratio of cyclic sulfides to ***thiol*** groups ranging from 0 to 1.0. In some aspects, the ***thiol*** ester molecules have an average ranging from 1.5 to 9 ***thiol*** groups per ***thiol*** ester molecule. In some embodiments, the ***thiol*** ester molecules have a molar ratio of carbon-carbon double bonds to ***thiol*** groups of less than 1.5.

SUMM The amount of ***thiol*** sulfur or ***mercaptan*** sulfur contained within the ***thiol*** ester molecules can also vary. For example, in some embodiments, the ***thiol*** ester molecules have an average of greater than 5 weight percent ***thiol*** sulfur. In other embodiments, the ***thiol*** ester molecules have an average ranging from 8 to 10 weight percent ***thiol*** sulfur. In some embodiments, the ***thiol*** ester molecules have an average of less than 30 mole percent sulfur, which is present as cyclic sulfides. Alternatively, the ***thiol*** ester molecules have an average of less than 2 mole percent sulfur present as cyclic sulfides.

SUMM In some embodiments, the ***thiol*** ester molecules are produced from unsaturated esters that have an average of less than 25 weight percent of side chains that include 3 contiguous methylene interrupted carbon-carbon double bonds. In another aspect, greater than 40

percent of the total side chains contained within the ***thiol*** ester molecules contain sulfur.

SUMM In addition to the ***thiol*** ester composition, a process for producing the ***thiol*** ester composition is advantageously provided as another embodiment of the present invention. To produce the ***thiol*** ester composition, hydrogen sulfide is contacted with an unsaturated ester composition. The unsaturated ester composition includes unsaturated esters that have an average of at least 1.5 ester groups per unsaturated ester molecule. The unsaturated esters also have an average of at least 1.5 carbon-carbon double bonds per unsaturated ester molecule. The hydrogen sulfide and the unsaturated esters are reacted to produce or form the ***thiol*** ester composition.

The ***thiol*** ester composition advantageously includes ***thiol*** ester molecules that have a molar ratio of cyclic sulfides to ***thiol*** groups of less than 1.5.

SUMM Another process for producing the ***thiol*** ester composition is advantageously provided as another embodiment of the present invention. In this process embodiment, the hydrogen sulfide and the unsaturated ester composition are contacted. The unsaturated ester composition includes unsaturated esters having an average of at least 1.5 ester groups per unsaturated ester molecule and having an average of at least 1.5 carbon-carbon double bonds per unsaturated ester molecule.

The hydrogen sulfide and the unsaturated esters are then reacted in a substantial absence of a solvent to form the ***thiol*** ester composition. The ***thiol*** ester composition includes ***thiol*** ester molecules. The ***thiol*** ester composition advantageously includes ***thiol*** ester molecules that have a molar ratio of cyclic sulfides to ***thiol*** groups of less than 1.5.

SUMM The resulting ***thiol*** ester molecules produced by this process possess advantageous characteristics. For example, in some embodiments, the ***thiol*** ester molecules have a molar ratio of the hydrogen

sulfide to carbon-carbon double bonds of greater than 2. As another example, in other embodiments, the ***thiol*** ester molecules have an average of greater than 5 weight percent ***thiol*** sulfur. In some aspects, greater than 40 percent of the ***thiol*** ester molecule total side chains contain sulfur.

SUMM As another embodiment of the present invention, another process for preparing the ***thiol*** ester composition is advantageously provided. In this embodiment, a polyol composition and a ***thiol*** carboxylic acid composition are contacted and reacted to produce the ***thiol*** ester composition. The ***thiol*** ester composition includes ***thiol*** ester molecules having an average of at least 1.5 ester groups per ***thiol*** ester molecule and having an average of at least 1.5 ***thiol*** groups per ***thiol*** ester molecule.

SUMM In addition to the ***thiol*** ester composition, other compositions are advantageously provided as embodiments of the present invention. For example, a hydroxy ***thiol*** ester composition is provided as another embodiment of the present invention. The hydroxyl ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules having an average of at least 1.5 ester groups per hydroxy ***thiol*** ester molecule and having an average of at least 1.5 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule.

SUMM As described herein, the .alpha.-hydroxy ***thiol*** groups contain an alcohol or hydroxy group and a ***thiol*** group within the same group. In embodiments of the present invention, the .alpha.-hydroxy ***thiol*** groups can be replaced with separate alcohol and ***thiol*** groups. In these embodiments, the same number of .alpha.-hydroxy groups can be used for the separate alcohol and ***thiol*** groups. For example, in some embodiments, the hydroxy ***thiol*** ester molecules have an average of at least 1.5 .alpha.-hydroxy ***thiol*** groups. In embodiments that contain separate alcohol and ***thiol*** groups, the hydroxy ***thiol*** ester molecules would contain an average of at least 1.5 alcohol

groups and an average of at least 1.5 ***thiol*** groups.

SUMM In some aspects, the hydroxy ***thiol*** ester molecules have an average ranging from 1.5 to 9 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule. In some embodiments, the ***thiol*** ester molecules have a molar ratio of carbon-carbon double bonds to ***thiol*** groups of less than 1.5.

SUMM In some embodiments, the ***thiol*** ester molecules are produced from unsaturated esters that have an average of less than 25 weight percent of side chains that include 3 contiguous methylene interrupted carbon-carbon double bonds. In another aspect, greater than 40 percent of the total side chains contained within the .alpha.-hydroxy ***thiol*** ester molecules contain sulfur.

SUMM The amount of ***thiol*** sulfur contained within the hydroxy ***thiol*** ester molecules can also vary. For example, in some embodiments, the hydroxy ***thiol*** ester molecules have an average of greater than 5 weight percent ***thiol*** sulfur. In other embodiments, the hydroxy ***thiol*** ester molecules have an average ranging from 8 to 10 weight percent ***thiol*** sulfur.

SUMM In some embodiments, the hydroxy ***thiol*** ester molecules have a molar ratio of ***epoxide*** groups to the .alpha.-hydroxy ***thiol*** groups of less than 2. In other aspects, the composition is substantially free of ***epoxide*** groups.

SUMM In addition to the hydroxy ***thiol*** ester composition, methods or processes for making the hydroxy ***thiol*** ester composition are advantageously provided as embodiments of the present invention. In an embodiment, a process for preparing the hydroxy ***thiol*** ester composition is provided that includes the step of contacting the hydrogen sulfide and an epoxidized unsaturated ester composition. The epoxidized unsaturated ester composition includes epoxidized esters having an average of at least 1.5 ester groups per epoxidized unsaturated ester molecule and having an average of at least 1.5 ***epoxide*** groups per epoxidized unsaturated ester molecule. The hydrogen sulfide and the epoxidized unsaturated esters are then

reacted
to form the hydroxy ***thiol*** ester composition.

SUMM In some embodiments, a molar ratio of the hydrogen sulfide to
epoxide groups in the epoxidized unsaturated esters is
greater than 1.

SUMM Another process for preparing the hydroxy ***thiol*** ester
composition is advantageously provided as another embodiment of
the present invention. In this process embodiment, a polyol
composition and a hydroxy ***thiol*** carboxylic acid composition are
contacted and reacted to produce the hydroxy ***thiol*** ester composition.
In this embodiment, the hydroxy ***thiol*** ester composition
includes hydroxy ***thiol*** ester molecules having an average of at
least 1.5 ester groups per hydroxy ***thiol*** ester molecule and
having an average of at least 1.5 .alpha.-hydroxy ***thiol*** groups
per hydroxy ***thiol*** ester molecule.

SUMM A cross-linked ***thiol*** ester composition is
advantageously provided as another embodiment of the present invention. The
cross-linked ***thiol*** ester composition includes
thiol ester oligomers having at least two ***thiol*** ester
monomers connected by a polysulfide linkage having a structure --
S.sub.Q-- , wherein Q is greater than 1. In some embodiments, the
thiol ester oligomers have at least three ***thiol*** ester
monomers connected by polysulfide linkages. In another aspect, the
thiol ester oligomers have from 3 to 20 ***thiol*** ester monomers
connected by polysulfide linkages.

SUMM In an aspect, the cross-linked ***thiol*** ester composition
includes both ***thiol*** ester monomers and ***thiol***
ester oligomers. In some embodiments, the ***thiol*** ester
monomers and ***thiol*** ester oligomers have a total ***thiol***
sulfur content ranging from 0.5 to 8 weight percent; or alternatively,
ranging from 8 to 15 weight percent. The combined ***thiol*** ester
monomers and ***thiol*** ester oligomers can have an average molecular
weight greater than 2000; or alternatively, in a range from 2000 to
20,000.

SUMM As another embodiment of the present invention, a cross-linked
thiol ester composition produced by the process
comprising the
steps of contacting the ***thiol*** ester composition with an
oxidizing agent and reacting the ***thiol*** ester and the
oxidizing
agent to form ***thiol*** ester oligomers is advantageously
provided. In this embodiment, the ***thiol*** ester oligomers
have
at least two ***thiol*** ester monomers connected by a
polysulfide
linkage having a structure --S.sub.Q--, wherein Q is greater than
1.

SUMM A process to produce the cross-linked ***thiol*** ester
composition
is also advantageously provided as another embodiment of the
present
invention. In this process, a ***thiol*** ester composition
is
contacted and reacted with an oxidizing agent to form
thiol
ester oligomers having at least two ***thiol*** ester
monomers
connected by a polysulfide linkage having a structure --
S.sub.Q--,
wherein Q is greater than 1. In some embodiments, the oxidizing
agent is
elemental sulfur, oxygen, or hydrogen peroxide. In an aspect, the
oxidizing agent is elemental sulfur.

SUMM In an aspect, the ***thiol*** ester is a hydroxy
thiol
ester. In other aspects, a weight ratio of elemental sulfur to
thiol sulfur in the ***thiol*** ester molecules
ranges from
0.5 to 32.

SUMM The step of the reacting the ***thiol*** ester and the
oxidizing
agent can be performed at a temperature ranging from 25.degree.
C. to
150.degree. C. The process for producing the cross-linked
thiol
ester composition can also include the step of stripping residual
hydrogen sulfide from the cross-linked ***thiol*** ester
composition
produced. In another aspect, the reaction of the ***thiol***
ester
and the elemental sulfur is catalyzed. In some embodiments, the
catalyst
is an amine.

SUMM In another of its aspects, the present invention relates to a
controlled release fertilizer material comprising a particulate
plant
nutrient surrounded by a coating which is the reaction product of
a
mixture comprising: (i) a first component selected from an

isocyanate
and/or an epoxy resin, and (ii) a first active hydrogen-
containing
compound selected from the group consisting of a ***thiol***
ester
composition; a hydroxy ***thiol*** ester composition; a
cross-linked
thiol ester composition and mixtures thereof.

SUMM In another of its aspects, the present invention relates to a
process
for the production of abrasion resistant polythiourethane and/or
epoxy
polymer encapsulated controlled release fertilizer particles by
incorporating in urethane and/or epoxy polymer forming reaction
mixture
a sulfur-containing compound such as one or more of a
thiol
ester composition; a hydroxy ***thiol*** ester composition; a
cross-linked ***thiol*** ester composition, other sulfur-
based
compounds described herein below and mixtures thereof.

SUMM Preferably, for the production of the present polythiourethane
encapsulated controlled release fertilizer material, a sulfur-
containing
compound (e.g., one or more of a ***thiol*** ester
composition; a
hydroxy ***thiol*** ester composition; a cross-linked
thiol
ester composition) is used as one of the isocyanate-reactive
components
(alone or in combination with other active hydrogen-containing
compounds). Preferably, the sulfur-containing compound comprises
a
sulfur-containing vegetable oil. In one preferred embodiment, the
sulfur-containing vegetable oil comprises a mercaptanized
vegetable oil
(MVO), more preferably as described in more detail herein, even
more
preferably an MVO produced by the addition of hydrogen sulfide to
a
vegetable oil. In another preferred embodiment, the sulfur-
containing
vegetable oil comprises mercapto-hydroxy vegetable oil (MHVO),
more
preferably as described in more detail herein, even more
preferably an
MHVO produced by the addition of hydrogen sulfide to epoxidized
vegetable oil. In yet another preferred embodiment, the sulfur
containing vegetable oil comprises sulfur cross-linked
mercaptanized
vegetable oil (CMVO), more preferably as described in more detail
herein, even more preferably an CMVO produced by the addition of
elemental sulfur to mercaptanized vegetable oil (MVO).

SUMM Preferably, for the production of epoxy polymer encapsulated
controlled
release fertilizer material, a sulfur-containing compound (e.g.,
one or

more of a ***thiol*** ester composition; a hydroxy
thiol ester composition; a cross-linked ***thiol*** ester
composition) is used as one of the isocyanate-reactive components (alone or in
combination with other active hydrogen-containing compounds).
Preferably, the sulfur-containing compound comprises a sulfur-
containing vegetable oil (e.g., MVO and/or MHVO and/or CMVO) is used as one
of the epoxy resin-reactive components.

DRWD FIG. 1 includes two graphs that compare the NMR's of soybean
oil, which is shown in the top graph, and a ***thiol*** containing ester
produced from soybean oil in accordance with an embodiment of the
present invention, which is shown in the bottom graph;

DRWD FIG. 2 includes two graphs that compare the NMR's of epoxidized
soybean oil, which is shown in the top graph, and a ***thiol***
containing ester produced from epoxidized soybean oil in accordance with an
embodiment of the present invention, which is shown in the bottom
graph;

DRWD FIG. 3 is a gas chromatograph (GC)/mass spectrometer (MS) trace
of a ***thiol*** containing ester that was produced from soybean
oil in accordance with an embodiment of the present invention and then
treated by methanolysis;

DRWD FIG. 5 is a GC/MS trace of hydroxy ***thiol*** containing
ester

produced from epoxidized soybean oil in accordance with an
embodiment of the present invention and then treated by methanolysis;

DETD In this specification, " ***thiol*** ester composition"
refers to an

ester composition that includes " ***thiol*** ester
molecules." The

thiol ester molecule has at least one ***thiol***
group and

at least one ester group within the ***thiol*** ester
molecule.

DETD In this specification, "hydroxy ***thiol*** ester
composition"

refers to an ester composition that includes "hydroxy

thiol ester molecules." The hydroxy ***thiol*** ester molecule has

at least one ***thiol*** group, at least one ester group, and at

least one hydroxy or alcohol group within the hydroxy ***thiol***

ester molecule. Alternatively, the alcohol group and the ***thiol***

group can be combined in the same group, which is referred to as an
".alpha.-hydroxy ***thiol*** group."

DETD In this specification, "polythiourethane" refers to a urethane
composition that includes more than one of the following

structure:
 ##STR1## The presence of the thiourethane group can be determined by method known to those skilled in the art (for example infrared spectroscopy, Raman spectroscopy, and/or NMR). ***Thiol***

Ester Composition
 DETD The present invention advantageously provides a ***thiol*** ester composition as an embodiment of the present invention. The ***thiol*** ester composition includes ***thiol*** ester molecules that have an average of at least 1.5 ester groups and an average of at least 1.5 ***thiol*** groups per ***thiol*** ester molecule. The ***thiol*** ester composition also has a molar ratio of cyclic sulfides to ***thiol*** groups of less than 1.5, as described herein.

DETD Generally, the ***thiol*** ester composition contains molecules having at least one ester group and at least one ***thiol*** group. The ***thiol*** ester composition of this invention can be produced from any unsaturated ester, as described herein. Because the feedstock unsaturated esters can contain multiple carbon-carbon double bonds per unsaturated ester molecule, carbon-carbon double bond reactivity and statistical probability dictate that each ***thiol*** ester molecule of the ***thiol*** ester composition produced from the unsaturated ester composition will not have the same number of ***thiol*** groups, number of unreacted carbon-carbon double bonds, number of cyclic sulfides, molar ratio of carbon-carbon double bonds to ***thiol*** groups, molar ratio of cyclic sulfides to ***thiol*** groups and other quantities of functional groups and molar ratios disclosed herein as the feedstock unsaturated ester. Additionally, the feedstock unsaturated esters can also comprise a mixture of individual unsaturated esters having a different number of carbon-carbon double bonds and/or ester groups. Thus, many of these properties will be discussed as an average number of the groups per ***thiol*** ester molecule within the ***thiol*** ester composition or average ratio per ***thiol*** ester molecule within the ***thiol*** ester composition. In other embodiments, it is desired to control the content of ***thiol***

sulfur present in the ***thiol*** ester. Because it is difficult to ensure that the hydrogen sulfide reacts with every carbon-carbon double bond within the unsaturated ester, certain molecules of ***thiol*** ester can have more or less ***thiol*** groups than other molecules. Thus, the weight percent of ***thiol*** groups is stated as an average across all ***thiol*** ester molecules of the ***thiol*** ester composition.

DETD The ***thiol*** ester can be derived from any unsaturated ester described herein.

DETD The ***thiol*** ester compositions can be described as comprising one or more separate or discreet functional groups of the ***thiol*** ester molecule and/or ***thiol*** ester composition. These independent functional groups can include: the number of (or average number of) ester groups per ***thiol*** ester molecule, ***thiol*** containing the number of (or average number of) ***thiol*** groups per ***thiol*** ester molecule, the number of (or average number of) unreacted carbon-carbon double bonds per ***thiol*** ester molecule, the average ***thiol*** sulfur content of the ***thiol*** ester composition, the percentage (or average percentage) of sulfide linkages per ***thiol*** ester molecule, and the percentage (or average percentage) of cyclic sulfide groups per ***thiol*** ester molecule. Additionally, the ***thiol*** ester compositions can be described using individual or a combination of ratios including the ratio of double bonds to ***thiol*** groups, the ratio of cyclic sulfides to ***mercaptan*** group, and the like.

As separate elements, these functional groups of the ***thiol*** composition will be described separately.

DETD Minimally, in some embodiments, the ***thiol*** ester contains ***thiol*** ester molecules having at least one ester group and one ***thiol*** group per ***thiol*** ester molecule. As the ***thiol*** ester is prepared from unsaturated esters, the ***thiol*** ester can contain the same number of ester groups as the unsaturated esters described herein. In an embodiment, the ***thiol*** ester molecules have an average of at least 1.5 ester groups per ***thiol*** ester molecule. Alternatively, the ***thiol*** ester

molecules have an average of at least 2 ester groups per
 thiol ester molecule; alternatively, an average of at least 2.5 ester
 groups per ***thiol*** ester molecule; or alternatively, an average
 of at least 3 ester groups per ***thiol*** ester molecule. In other
 1.5 to 8 embodiments, the ***thiol*** esters have an average of from
 ester groups per ***thiol*** ester molecule; alternatively,
 an average of from 2 to 7 ester groups per ***thiol*** ester
 molecule;
 alternatively, an average of from 2.5 to 5 ester groups per
 thiol ester molecule; or alternatively, an average of
 from 3 to 4 ester groups per ***thiol*** ester molecule. In yet other
 embodiments, the ***thiol*** ester comprises an average of 3
 ester groups per ***thiol*** ester molecule or alternatively, an
 average of 4 ester groups per unsaturated ester molecule.
 DETD Minimally, the ***thiol*** ester comprises an average of at
 least one ***thiol*** group per ***thiol*** ester molecule. In
 an embodiment, the ***thiol*** ester molecules have an average
 of at least 1.5 ***thiol*** groups per ***thiol*** ester
 molecule;
 alternatively, ***thiol*** containing an average of at least
 2 ***thiol*** groups per ***thiol*** ester molecule;
 alternatively,
 an average of at least 2.5 ***thiol*** groups per
 thiol ester molecule; or alternatively, an average of at least 3
 thiol groups per ***thiol*** ester molecule. In other embodiments,
 the ***thiol*** ester molecules have an average of from 1.5 to 9
 thiol groups per ***thiol*** ester molecule;
 alternatively,
 an average of from 3 to 8 ***thiol*** groups per
 thiol ester molecule; alternatively, ***thiol*** containing an
 average of from 2 to 4 ***thiol*** groups per ***thiol*** ester
 molecule,
 or alternatively, an average of from 4 to 8 ***thiol***
 groups per ***thiol*** ester molecule.
 DETD In other embodiments, the ***thiol*** ester can be described
 by the average amount of ***thiol*** sulfur present in ***thiol***
 ester. In an embodiment, the ***thiol*** ester molecules have
 an average of at least 5 weight percent ***thiol*** sulfur per
 thiol ester molecule; alternatively, an average of at
 least 10

weight percent ***thiol*** sulfur per ***thiol*** ester molecule, or alternatively, an average of greater than 15 weight percent ***thiol*** sulfur per ***thiol*** ester molecule. In an embodiment, the ***thiol*** ester molecules have an average of from 5 to 25 weight percent ***thiol*** sulfur per ***thiol*** ester molecule; alternatively, an average of from 5 to 20 weight percent ***thiol*** sulfur per ***thiol*** ester molecule; alternatively, an average of from 6 to 15 weight percent ***thiol*** sulfur per ***thiol*** ester molecule; or alternatively, an average of from 8 to 10 weight percent ***thiol*** sulfur per ***thiol*** ester molecule.

DETD Generally, the location of the ***thiol*** group of the ***thiol*** ester is not particularly important and will be dictated by the method used to produce the ***thiol*** ester. In embodiments wherein the ***thiol*** ester is produced by contacting an unsaturated ester, the position of the ***thiol*** group will be dictated by the position of the carbon-carbon double bond. When the carbon-carbon double bond is an internal carbon-carbon double bond, the method of producing the ***thiol*** ester will result in a secondary ***thiol*** group. However, when the double bond is located at a terminal position it is possible to choose reaction conditions to produce a ***thiol*** ester comprising either a primary ***thiol*** group or a secondary ***thiol*** group.

DETD Some methods of producing the ***thiol*** ester composition can additionally create sulfur containing functional groups other than a ***thiol*** group. For example, in some ***thiol*** ester production methods, an introduced ***thiol*** group can react with a carbon-carbon double bond within the same unsaturated ester to produce a sulfide linkage. When the reaction is with a double bond of a second unsaturated ester, this produces a simple sulfide linkage.

However, in some instances, the second carbon-carbon double bond is located in the same unsaturated ester molecule. When the ***thiol*** group reacts with a second carbon-carbon double bond within the same unsaturated ester molecule, a sulfide linkage is produced. In some instances, the carbon-carbon double bond can be within a second ester group of

the unsaturated ester molecule. While in other instances, the carbon-carbon double bond can be within the same ester group of the unsaturated ester molecule.

DETD When the ***thiol*** group reacts with the carbon-carbon double bond in a second ester group of the same unsaturated ester molecule, the cyclic sulfide would contain two ester groups contained within a ring structure. When the ***thiol*** group reacts with the carbon-carbon double bond within the same ester group, the cyclic sulfide would not contain an ester group within the ring structure. Within this specification, this second type of cyclic sulfide is referred to as a cyclic sulfide. Within this specification, the first type of cyclic sulfide is referred to as a simple sulfide. In the cyclic sulfide case, the sulfide linkage produces a cyclic sulfide functionality within a single ester group of the ***thiol*** ester. This linkage is termed a cyclic sulfide for purposes of this application. One such sulfide group that can be produced is a cyclic sulfide. The cyclic sulfide rings that can be produced include a tetrahydrothiopyran ring, a thietane ring, or a thiophane ring (tetrahydrothiophene ring).

DETD In some embodiments, it is desirable to control the average amount of sulfur present as cyclic sulfide in the ***thiol*** ester. In an embodiment the average amount of sulfur present as cyclic sulfide in the ***thiol*** ester molecules comprises less than 30 mole percent.

Alternatively, the average amount of sulfur present as cyclic sulfide in the ***thiol*** esters comprises less than 20 mole percent; alternatively, less than 10 mole percent; alternatively, less than 5 mole percent; or alternatively, less than 2 mole percent. In other

embodiments, it is desired to control the molar ratio of cyclic sulfides to ***thiol*** groups. In other embodiments, it is desirable to have molar ratios of cyclic sulfide to ***thiol*** group. In an embodiment, the average molar ratio of cyclic sulfide groups to ***thiol*** group per ***thiol*** ester is less than 1.5.

Alternatively, the average molar ratio of cyclic sulfide groups to ***thiol*** group per ***thiol*** ester is less than 1; alternatively, less than 0.5; alternatively, less than 0.25; or

alternatively, 0.1. In some embodiments, the ratio of cyclic sulfide groups to ***thiol*** group per ***thiol*** ester ranges from 0 to 1; or alternatively, the average molar ratio of cyclic sulfide groups to ***thiol*** group per ***thiol*** ester ranges between 0.05 and 1.

DETD In some instances it can be desirable to have carbon-carbon double bonds present in the ***thiol*** ester composition while in other embodiments it can be desirable to minimize the number of carbon-carbon double bonds present in the ***thiol*** ester composition.

The presence of carbon-carbon double bonds present in the ***thiol*** ester can be stated as an average molar ratio of carbon-carbon double bonds to ***thiol*** -sulfur. In an embodiment, the average ratio of the remaining unreacted carbon-carbon double bond in the ***thiol*** ester composition to ***thiol*** sulfur is less than 1.5 per ***thiol*** ester molecule. Alternatively, the average ratio of carbon-carbon double bond to ***thiol*** sulfur is less than 1.2 per ***thiol*** ester molecule; alternatively, less than 1.0 per ***thiol*** ester molecule; alternatively, less than 0.75 per ***thiol*** ester molecule; alternatively, less than 0.5 per ***thiol*** ester molecule; alternatively, less than 0.2 per ***thiol*** ester molecule; or alternatively, less than 0.1 per ***thiol*** ester molecule.

DETD In particular embodiments, the ***thiol*** ester is produced from unsaturated ester compositions. Because the feedstock unsaturated ester has particular compositions having a certain number of ester groups present, the product ***thiol*** ester composition will have about the same number of ester groups per ***thiol*** ester molecule as the feedstock unsaturated ester. Other, independent ***thiol*** ester properties described herein can be used to further describe the ***thiol*** ester composition.

DETD In some embodiments, the ***thiol*** ester molecules are produced from unsaturated esters having an average of less than 25 weight percent of side chains having 3 contiguous methylene interrupted carbon-carbon double bonds, as described herein. In some embodiments, greater than 40 percent of the ***thiol*** containing natural source total side

chains can include sulfur. In some embodiments, greater than 60 percent of the ***thiol*** ester molecule total side chains can include sulfur. In other embodiments, greater than 50, 70, or 80 percent of the ***thiol*** ester molecule total side chains can include sulfur.

DETD In an embodiment, the ***thiol*** ester is a ***thiol*** containing natural source oil, as described herein. When the ***thiol*** ester is a ***thiol*** containing natural source oil, functional groups that are present in the ***thiol*** containing natural source oil can be described in a "per ***thiol*** ester molecule" basis or in a "per triglyceride" basis. The ***thiol*** containing natural source oil can have substantially the same properties as the ***thiol*** ester composition, such as the molar ratios and other independent descriptive elements described herein.

DETD The average number of ***thiol*** groups per triglyceride in the ***thiol*** containing natural source oil is greater than about 1.5.

In some embodiments, the average number of ***thiol*** groups per triglyceride can range from about 1.5 to about 9.

DETD The ***thiol*** ester compositions can also be described as a product produced by the process comprising contacting hydrogen sulfide and an unsaturated ester composition and can be further limited by the process as described herein. The ***thiol*** containing natural source oil can also be described using a molecular weight or an average molecular weight of the side chains.

DETD Hydroxy ***Thiol*** Ester Composition

DETD In embodiments of the present invention, the ***thiol*** ester compositions can also contain a hydroxy or alcohol group. When the ***thiol*** ester composition includes the hydroxy group, the ***thiol*** ester composition is referred to herein as the hydroxy ***thiol*** ester composition. The quantity or number of alcohol groups present in the hydroxy ***thiol*** ester composition can be independent of the quantity of other functional groups present in the hydroxy ***thiol*** ester composition (i.e. ***thiol*** ester groups, sulfides, cyclic sulfides). Additionally, the weight percent of ***thiol*** sulfur and functional group ratios

(i.e. molar ratio of cyclic sulfides to ***thiol*** groups, molar ratio of ***epoxide*** groups to ***thiol*** groups, molar ratio of ***epoxide*** groups to .alpha.-hydroxy ***thiol*** groups and other disclosed quantities of functional groups and their molar ratios to the ***thiol*** groups) are separate or discreet elements that can be used to describe the hydroxy ***thiol*** ester composition. The hydroxy ***thiol*** ester composition can be described using any combination of the hydroxy ***thiol*** ester composition separate functional groups or ratios described herein. DETD In an embodiment, the hydroxy ***thiol*** ester composition is produced by reacting hydrogen sulfide with an epoxidized unsaturated ester composition as described herein. Because the epoxidized unsaturated ester can contain multiple ***epoxide*** groups, ***epoxide*** group reactivity and statistical probability dictate that not all hydroxy ***thiol*** ester molecules of the hydroxy ***thiol*** ester composition will have the same number of hydroxy groups, ***thiol*** groups, .alpha.-hydroxy ***thiol*** groups, sulfides, cyclic sulfides, molar ratio of cyclic sulfides to ***thiol*** groups, molar ratio of ***epoxide*** groups to ***thiol*** groups, molar ratio of ***epoxide*** groups to .alpha.-hydroxy ***thiol*** groups, weight percent ***thiol*** sulfur and other disclosed quantities of functional groups and their molar ratios as the epoxidized unsaturated ester composition. Thus, many of these properties will be discussed as an average number or ratio per hydroxy ***thiol*** ester molecule. In other embodiments, it is desired to control the content of ***thiol*** sulfur present in the hydroxy ***thiol*** ester. Because it is difficult to ensure that the hydrogen sulfide reacts with every ***epoxide*** group within the epoxidized unsaturated ester, certain hydroxy ***thiol*** ester molecules can have more or less ***thiol*** groups than other molecules within the hydroxy ***thiol*** ester composition. Thus, the weight percent of ***thiol*** groups can be stated as an average

weight percent across all hydroxy ***thiol*** ester molecules.

DETD As an embodiment of the present invention, the hydroxy ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules that have an average of at least 1 ester groups and an average of at least 1 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule. As an embodiment of the present invention, the hydroxy ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules that have an average of at least 1.5 ester groups and an average of at least 1.5 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule.

DETD Minimally, in some embodiments, the hydroxy ***thiol*** ester comprises at least one ester, at least one ***thiol*** group, and at least one hydroxy group. Because the hydroxy ***thiol*** ester is prepared from epoxidized unsaturated esters, the hydroxy ***thiol*** ester can contain the same number of ester groups as the epoxidized unsaturated esters. In an embodiment, the hydroxy ***thiol*** ester molecules have an average of at least 1.5 ester groups per hydroxy ***thiol*** ester molecule. Alternatively, the hydroxy ***thiol*** ester molecules have an average of at least 2 ester groups per hydroxy ***thiol*** ester molecule; alternatively, an average of at least 2.5 ester groups per hydroxy ***thiol*** ester molecule; or alternatively, an average of at least 3 ester groups per hydroxy ***thiol*** ester molecule. In other embodiments, the hydroxy ***thiol*** esters have an average of from 1.5 to 8 ester groups per hydroxy ***thiol*** ester molecule; alternatively, an average of from 2 to 7 ester groups per hydroxy ***thiol*** ester molecule; alternatively, an average of from 2.5 to 5 ester groups per hydroxy ***thiol*** ester molecule; or alternatively, an average of from 3 to 4 ester groups per hydroxy ***thiol*** ester molecule. In yet other embodiments, the .alpha.-hydroxy ***thiol*** ester comprises an average of 3 ester groups per hydroxy ***thiol*** ester molecule or alternatively, an average of 4 ester groups per hydroxy ***thiol*** ester molecule.

DETD In some embodiments, the hydroxy group and the hydroxy group are combined in the same group, which produces the .alpha.-hydroxy group. In other embodiments, the group and the hydroxy or alcohol group are not in the same group. When this occurs, to produce the hydroxy ester composition, the alcohol group is added independently of the ester group. For example, as another embodiment of the present invention, the hydroxy ester composition advantageously includes hydroxy ester molecules. The hydroxy ester molecules have an average of at least 1.5 ester groups, an average of at least 1.5 groups, and an average of at least 1.5 alcohol groups per hydroxy ester molecule.

DETD Minimally, in some embodiments, the hydroxy ester comprises at least one group per hydroxy ester molecule. In an embodiment, the hydroxy ester molecules have an average of at least 1.5 groups per hydroxy ester molecule; alternatively, an average of at least 2 groups per hydroxy ester molecule; alternatively, an average of at least 2.5 groups per hydroxy ester molecule; or alternatively, an average of at least 3 groups per hydroxy ester molecule. In other embodiments, the hydroxy ester molecules have an average of from 1.5 to 9 groups per hydroxy ester molecule; alternatively, an average of from 3 to 8 groups per hydroxy ester molecule; alternatively, an average of from 2 to 4 groups per hydroxy ester molecule; or alternatively, an average of from 4 to 8 groups per hydroxy ester.

DETD Minimally, in some embodiments, the hydroxy ester composition comprises an average of at least 1 hydroxy or alcohol group per hydroxy ester molecule. In some embodiments, the hydroxy ester composition comprises an average of at least 1.5 hydroxy groups per hydroxy ester

molecule;
alternatively, average of at least 2 hydroxy groups per hydroxy
thiol ester molecule; alternatively, an average of at
least 2.5
hydroxy groups per hydroxy ***thiol*** ester molecule; or
alternatively, an average of at least 3 hydroxy groups per
thiol
ester molecule. In other embodiments, the ***thiol*** ester
composition comprises an average of from 1.5 to 9 hydroxy groups
per
hydroxy ***thiol*** ester molecule; alternatively, an average
of
from 3 to 8 hydroxy groups per hydroxy ***thiol*** ester
molecule;
alternatively, an average of from 2 to 4 hydroxy groups per
hydroxy
thiol ester molecule; or alternatively, an average of
from 4 to
8 hydroxy groups per hydroxy ***thiol*** ester molecule.
DETD In yet other embodiments, the number of hydroxy groups can be
stated as
an average molar ratio of hydroxy group to ***thiol***
groups.
Minimally, in some embodiments, the molar ratio of hydroxy groups
to
thiol groups is at least 0.25. In some embodiments, the
molar
ratio of hydroxy groups to ***thiol*** groups is at least
0.5;
alternatively, at least 0.75; alternatively, at least 1.0;
alternatively, at least 1.25; or alternatively, at least 1.5. In
other
embodiments, the molar ratio of hydroxy groups to ***thiol***
groups
ranges from 0.25 to 2.0; alternatively, from 0.5 to 1.5; or
alternatively, from 0.75 to 1.25.
DETD In embodiments where the hydroxy ***thiol*** esters are
produced
from an epoxidized unsaturated ester, the hydroxy ***thiol***
esters
can be described as containing ester groups and .alpha.-hydroxy
thiol groups. The number of ester groups and the number
of
.alpha.-hydroxy ***thiol*** groups are independent elements
and as
such the hydroxy ***thiol*** esters can be described as
having any
combination of ester groups and .alpha.-hydroxy ***thiol***
groups
described herein. Minimally, the hydroxy ***thiol*** ester
comprises
an average of at least 1 .alpha.-hydroxy ***thiol*** group
per
hydroxy ***thiol*** ester molecule. In some embodiments, the
hydroxy
thiol ester composition comprises an average of at
least 1.5
.alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol***
ester
molecule; alternatively, an average of at least 2 .alpha.-hydroxy

thiol groups per hydroxy ***thiol*** ester molecule;
 alternatively, an average of at least 2.5 .alpha.-hydroxy
 thiol groups per hydroxy ***thiol*** ester molecule; or
 alternatively, an average of at least 3 .alpha.-hydroxy ***thiol*** groups per hydroxy
 thiol ester molecule. In other embodiments, the hydroxy
 thiol ester composition comprises an average of from 1.5 to 9 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule; alternatively, an average of from 3 to 8 .alpha.-hydroxy
 thiol groups per hydroxy ***thiol*** ester molecule;
 alternatively, an average of from 2 to 4 .alpha.-hydroxy
 thiol groups per hydroxy ***thiol*** ester molecule; or
 alternatively, an average of from 4 to 8 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule.
 DETD The hydroxy ***thiol*** esters can be produced by contacting an epoxidized ester derived from an unsaturated ester (i.e., epoxidized unsaturated ester), as described herein. In some instances it can be desirable to have ***epoxide*** groups present in the hydroxy ***thiol*** ester composition. While in other embodiments, it can be desirable to minimize the number of epoxy groups present in the hydroxy ***thiol*** ester composition. Thus, the presence of residual ***epoxide*** groups can be another separate functional group used to describe the hydroxy ***thiol*** ester.
 DETD The presence of ***epoxide*** groups in the hydroxy ***thiol*** ester can be independently described as an average number of ***epoxide*** groups per hydroxy ***thiol*** ester, a molar ratio of ***epoxide*** groups to ***thiol*** groups, a molar ratio of ***epoxide*** groups to .alpha.-hydroxy ***thiol*** groups, or any combination thereof. In some embodiments, the hydroxy ***thiol*** ester molecules comprise an average of less than 2 ***epoxide*** groups per hydroxy ***thiol*** ester molecule, i.e., the hydroxy ***thiol*** ester molecules have a molar ratio of ***epoxide*** groups to .alpha.-hydroxy ***thiol*** groups of less than 2. Alternatively, the hydroxy ***thiol*** ester comprises an average of less than 1.5 ***epoxide*** groups per hydroxy ***thiol*** ester molecule; alternatively, an average of less than 1

epoxide
 group per hydroxy ***thiol*** ester molecule; alternatively,
 an
 average of less than 0.75 ***epoxide*** groups per hydroxy
 thiol ester molecule; or alternatively, an average of
 less than
 0.5 ***epoxide*** groups per hydroxy ***thiol*** ester
 molecule.
 In other embodiments, the molar ratio of ***epoxide*** groups
 to
 thiol groups averages less than 1.5. Alternatively, the
 molar
 ratio of ***epoxide*** groups to ***thiol*** groups
 averages
 less than 1; alternatively, averages less than 0.75;
 alternatively,
 averages less than 0.5; alternatively, averages less than 0.25;
 or
 alternatively, averages less than 0.1. In yet other embodiments,
 the
 molar ratio of ***epoxide*** groups to .alpha.-hydroxy
 thiol
 groups averages less than 1.5. Alternatively, the molar ratio of
 epoxide groups to .alpha.-hydroxy ***thiol***
 groups
 averages less than 1; alternatively, averages less than 0.75;
 alternatively, averages less than 0.5; alternatively, averages
 less than
 0.25; or alternatively, averages less than 0.1.
 DETD In some embodiments, the hydroxy ***thiol*** ester
 composition is
 substantially free of ***epoxide*** groups.
 DETD In other embodiments, the hydroxy ***thiol*** ester can be
 described by the average amount of ***thiol*** sulfur present
 in
 hydroxy ***thiol*** ester. In an embodiment, the hydroxy
 thiol ester molecules have an average of at least 2.5
 weight
 percent ***thiol*** sulfur per hydroxy ***thiol*** ester
 molecule; alternatively, an average of at least 5 weight percent
 thiol sulfur per hydroxy ***thiol*** ester
 molecule;
 alternatively, an average of at least 10 weight percent
 thiol
 sulfur per hydroxy ***thiol*** ester molecule; or
 alternatively, an
 average of greater than 15 weight percent ***thiol*** sulfur
 per
 hydroxy ***thiol*** ester molecule. In an embodiment, the
 hydroxy
 thiol ester molecules have an average of from 5 to 25
 weight
 percent ***thiol*** sulfur per hydroxy ***thiol*** ester
 molecule; alternatively, an average of from 5 to 20 weight
 percent
 thiol sulfur per hydroxy ***thiol*** ester
 molecule;
 alternatively, an average of from 6 to 15 weight percent
 thiol
 sulfur per hydroxy ***thiol*** ester molecule; or

alternatively, an average of from 8 to 10 weight percent ***thiol*** sulfur per hydroxy ***thiol*** ester molecule.

DETD In some embodiments, at least 20 percent of the total side chains include the .alpha.-hydroxy ***thiol*** group. In some embodiments, at least 20 percent of the total side chains include the .alpha.-hydroxy ***thiol*** group. In some embodiments, at least 60 percent of the total side chains include the .alpha.-hydroxy ***thiol*** group; alternatively, at least 70 percent of the total side chains include the .alpha.-hydroxy ***thiol*** group. Yet in other embodiments, at least 80 percent of the total side chains include the .alpha.-hydroxy ***thiol*** group.

DETD In some aspects, greater than 20 percent of the hydroxy ***thiol*** ester molecule total side chains contain sulfur. In some aspects, greater than 40 percent of the hydroxy ***thiol*** ester molecule total side chains contain sulfur. In some aspects, greater than 60 percent of the hydroxy ***thiol*** ester molecule total side chains contain sulfur; alternatively, greater than 70 percent of the total side chains contain sulfur; or alternatively, greater than 80 percent of the total side chains contain sulfur.

DETD In particular embodiments, the epoxidized unsaturated ester used in the synthesis of the hydroxy ***thiol*** ester is produced from the epoxidized unsaturated ester composition that includes an epoxidized natural source oil. Because the natural source oils have particular compositions regarding the number of ester groups present, the hydroxy ***thiol*** ester will have about the same number of ester groups as the feedstock natural source oil. Other independent properties that are described herein can be used to further describe the hydroxy ***thiol*** ester.

DETD In other embodiments, the epoxidized unsaturated ester used to produce the hydroxy ***thiol*** ester is produced from synthetic (or semi-synthetic) unsaturated ester oils. Because the synthetic ester oils can have particular compositions regarding the number of ester groups present, the hydroxy ***thiol*** ester would have about the same number of ester groups as the synthetic ester oil. Other,

independent properties of the unsaturated ester, whether the unsaturated ester includes natural source or synthetic oils, can be used to further describe the hydroxy ***thiol*** ester composition.

DETD The hydroxy ***thiol*** ester compositions can also be described as a product produced by the process comprising contacting hydrogen sulfide and an epoxidized unsaturated ester composition and can be further limited by the process as described herein. The hydroxy ***thiol*** containing natural source oil can also be described using an average molecular weight or an average molecular weight of the side chains.

DETD Cross-Linked ***Thiol*** Ester Compositions

DETD In an aspect, the present invention relates to a cross-linked ***thiol*** ester composition. Generally, the cross-linked ***thiol*** ester molecules are oligomers of ***thiol*** esters that are connected together by polysulfide linkages --S.sub.x-- wherein x is an integer greater 1. As the cross-linked ***thiol*** ester is described as an oligomer of ***thiol*** esters, the ***thiol*** esters can be described as the monomer from which the cross-linked ***thiol*** esters are produced.

DETD In an aspect, the cross-linked ***thiol*** ester composition comprises a ***thiol*** ester oligomer having at least two ***thiol*** ester monomers connected by a polysulfide linkage having a structure --S.sub.Q--, wherein Q is an integer greater than 1. In an aspect, the polysulfide linkage may be the polysulfide linkage --S.sub.Q--, wherein Q is 2, 3, 4, or mixtures thereof. In other embodiments, Q can be 2; alternatively, 3; or alternatively, 4.

DETD In an aspect, the cross-linked ***thiol*** ester composition comprises a ***thiol*** ester oligomer having at least 3 ***thiol*** ester monomers connected by polysulfide linkages; alternatively, 5 ***thiol*** ester monomers connected by polysulfide linkages; alternatively, 7 ***thiol*** ester monomers connected by polysulfide linkages; or alternatively, 10 ***thiol*** ester monomers connected by polysulfide linkages. In yet other embodiments, the cross-linked ***thiol*** ester composition comprises a ***thiol*** ester oligomer having from 3 to 20 ***thiol*** ester monomers connected by polysulfide linkages; alternatively, from 5 to 15 ***thiol*** ester monomers connected by polysulfide linkages; or alternatively, from 7 to 12 ***thiol*** ester monomers connected by polysulfide linkages.

DETD In an aspect, the cross-linked **thiol** ester composition comprises **thiol** ester monomers and **thiol** ester oligomers. In some embodiments, the cross-linked **thiol** ester composition has a combined **thiol** ester monomer and **thiol** ester oligomer average molecular weight greater than 2,000. In other embodiments, the cross-linked **thiol** ester composition has a combined **thiol** ester monomer and **thiol** ester oligomer average molecular weight greater than 5,000; or alternatively, greater than 10,000. In yet other embodiments, the cross-linked **thiol** ester composition has a combined **thiol** ester monomer and **thiol** ester oligomer average molecular weight ranging from 2,000 to 20,000; alternatively, from 3,000 to 15,000; or alternatively, from 7,500 to 12,500.

DETD In an aspect, the **thiol** ester monomers and **thiol** ester oligomers have a total **thiol** sulfur content greater than 0.5. In other embodiments, the **thiol** ester monomers and **thiol** ester oligomers have a total **thiol** sulfur content greater than 1; alternatively, greater than 2; alternatively, greater than 4. In yet other embodiments, the **thiol** ester monomers and the **thiol** ester oligomers have a total **thiol** sulfur content from 0.5 to 8; alternatively, from 4 to 8; or alternatively, 0.5 to 4.

DETD In an aspect, the **thiol** ester monomers and **thiol** ester oligomers have a total sulfur content greater than 8. In some embodiments, the **thiol** ester monomers and **thiol** ester oligomers have a total sulfur content greater than 10; alternatively, greater than 12. In yet other embodiments, the **thiol** ester monomers and **thiol** ester oligomers have a total sulfur content ranging from 8 to 15 weight percent; alternatively, from 9 to 14; or alternatively, from 10 to 13.

DETD The cross-linked **thiol** ester compositions can also be described as a product produced by the process comprising contacting a **thiol** ester with oxidizing agent and can be further limited by the process as described herein.

DETD The present invention advantageously includes sulfide-containing ester compositions as embodiments of the present invention. Generally, the sulfide-containing ester compositions can be described as containing

molecules having at least one ester group and a least one sulfide group within each molecule. The sulfide-containing esters used in the present invention can be produced by contacting either an unsaturated ester or an epoxidized unsaturated ester with a ***thiol*** containing compound as described herein.

DETD The feedstock unsaturated esters can contain multiple carbon-carbon double bonds per unsaturated ester molecule. The carbon-carbon double bond reactivity and statistical probability, however, dictate that each sulfide-containing ester molecule of the ***thiol*** - containing ester composition produced from the unsaturated ester composition will not have the same number of sulfide groups, number of unreacted carbon-carbon double bonds, molar ratio of carbon-carbon double bonds to sulfide groups, molar ratio of cyclic sulfides to ***thiol*** groups and other herein disclosed quantities of functional groups and molar ratios. Additionally, the feedstock unsaturated esters can also comprise a mixture of individual unsaturated esters having a different number of carbon-carbon double bonds and/or ester groups. Many of these properties are discussed herein as an average number of the groups per sulfide-containing ester molecule within the sulfide-containing ester composition or average ratio per ***thiol*** -containing ester molecule within the sulfide-containing ester composition.

DETD In embodiments related to the sulfide-containing ester that is produced from an epoxidized unsaturated ester, the feedstock epoxidized unsaturated esters can contain multiple ***epoxide*** groups per unsaturated ester molecule. Individual ***epoxide*** group reactivity and statistical probability dictate that each sulfide-containing ester molecule of the sulfide-containing ester composition produced from the unsaturated ester composition will not have the same number of sulfide groups, number of unreacted ***epoxide*** groups, molar ratio of ***epoxide*** groups to sulfide groups, and other herein disclosed quantities of functional groups and molar ratios. Additionally, the feedstock epoxidized unsaturated esters can also comprise a mixture of individual epoxidized unsaturated ester molecules having a different number of ***epoxide*** groups and/or ester groups. Thus, many of these properties are described as an average number of the groups per sulfide-containing ester molecules within the sulfide-containing ester composition or

average ratio per ***thiol*** -containing ester molecule within the sulfide-containing ester composition.

DETD Minimally, in some embodiments, the sulfide-containing esters comprise at least one ester group per sulfide-containing ester molecule.

In some embodiments, the sulfide-containing ester has an average of at least 1.5 ester groups per sulfide-containing ester molecule.

Alternatively, the sulfide-containing ester molecules have an average of at least 2 ester groups per sulfide-containing ester molecule; alternatively, an average of at least 2.5 ester groups per sulfide-containing ester molecule; or alternatively, an average of at least 3 ester groups per sulfide-containing ester molecule. In other embodiments, the sulfide-containing esters have an average of from 1.5 to 9 ester groups per sulfide-containing ester molecule; alternatively, an average of from 1.5 to 8 ester groups per sulfide-containing ester molecule; alternatively, an average of from 2 to 8 ester groups per sulfide-containing ester molecule; alternatively, an average of from 2 to 7 ester groups per sulfide-containing ester molecule; alternatively, an average of from 2.5 to 5 ester groups per sulfide-containing ester molecule; alternatively, an average of from 3 to 5 ester groups per sulfide-containing ester molecule; or alternatively, an average of from 3 to 4 ester groups per sulfide-containing ester molecule. In yet other embodiments, the hydroxy ***thiol*** -containing ester comprises an average of about 3 ester groups per sulfide-containing ester molecule; or alternatively, an average of about 4 ester groups per sulfide-containing ester molecule.

DETD In some embodiments, R.sup.3 comprises at least one functional group. In one aspect, the functional group is selected from the group consisting of a hydroxy group, a carboxylic acid group, a carboxylic ester group, an amine group, a sulfide group, and a second ***thiol*** group. In some aspects, R.sup.3 comprises at least two functional groups. In some aspects, the functional groups are selected from the group consisting of a hydroxy group, carboxylic acid group, a carboxylic ester group, an amine group, a sulfide group, a second ***thiol*** group, and mixtures thereof.

DETD The sulfide-containing ester compositions can also be described as a

product produced by the process comprising contacting an unsaturated ester with a ***mercaptan*** and can be further limited by the process as described herein. In other embodiments, the sulfide-containing ester composition can also be described as a product produced by a process comprising contacting an epoxidized unsaturated ester with a ***mercaptan*** and can be further limited by the process as described herein.

DETD Generally, the thioacrylate ester composition can be described as comprising thioacrylate molecules having at least one ester group in addition to any acrylate or thioacrylate ester groups present in the thioacrylate molecule and at least one thioacrylate group. The ester group(s) that are in addition to any acrylate or thioacrylate ester groups present in the thioacrylate molecule are hereinafter referred to as "supplementary ester group(s)." The thioacrylate ester composition described herein can be produced by contacting an acrylate composition with a ***thiol*** -containing ester composition and/or a hydroxy ***thiol*** -containing ester composition, both of which are described herein.

DETD The feedstock ***thiol*** ester compositions and/or hydroxy ***thiol*** ester compositions can comprise a mixture of molecules that have an average quantity of ester groups, ***thiol*** groups, hydroxy groups, and other groups and molar ratios described herein. Additionally, individual ***thiol*** and hydroxy group reactivity within the ***thiol*** -containing ester compositions and/or hydroxy ***thiol*** ester compositions and statistical probability dictate that each thioacrylate ester molecule of the thioacrylate ester composition produced may not have the same number of ester groups, thioacrylate groups, acrylate groups, and other herein disclosed quantities of functional groups, moieties, and molar ratios.

Thus, many of the properties of the thioacrylate ester molecules within the thioacrylate ester composition are described as using an average number of the groups per thioacrylate ester molecule within the thioacrylate ester composition or as an average ratio per thioacrylate ester molecule within the thioacrylate ester composition.

DETD The thioacrylate ester can also be described as a product produced by the process that includes contacting a ***thiol*** -containing ester composition with an acrylate composition and can be further limited by the process described herein. In other embodiments, the thioacrylate ester composition can also be described as a product produced by a process that includes contacting a hydroxy ***thiol*** -containing ester composition with an acrylate composition and can be further limited by the process described herein.

DETD The present invention advantageously provides a sulfonic acid-containing ester as an embodiment of the present invention. Generally, the sulfonic acid-containing ester of the present invention includes sulfonic acid-containing ester molecules having at least one ester group and a least one sulfonic acid group. The sulfonic acid-containing ester described herein can be produced by contacting a ***thiol*** ester with an oxidizing agent as described herein. Because the feedstock for the production of the sulfonic acid-containing ester can include multiple ***thiols*** groups, ***thiol*** reactivity and statistical probability dictate that each sulfonic acid-containing ester molecule of the sulfonic acid-containing ester will not have the same number of sulfonic acid groups. Additionally, the feedstock ***thiol*** ester can also include a mixture of individual ***thiol*** ester molecules having different numbers of groups and/or ester groups. Thus, many of the groups present in the sulfonic acid-containing ester are described herein as an average number of the groups per sulfonic acid-containing ester molecule or an average ratio per sulfonic acid-containing ester molecule within the sulfonic acid-containing ester.

DETD In some embodiments of the present invention, the sulfonic acid ester is substantially free of ***thiol*** groups.

DETD The sulfonic acid-containing ester can also be described as a product produced by the process comprising contacting a ***thiol*** ester with an oxidizing agent described herein.

DETD Process for Making a ***Thiol*** Ester Composition

DETD The present invention advantageously provides processes for producing a ***thiol*** ester composition as embodiments of the present invention.

As an embodiment, the present invention advantageously includes a process to produce a ***thiol*** ester composition by contacting

hydrogen sulfide and an unsaturated ester composition containing unsaturated esters and reacting the hydrogen sulfide and unsaturated esters to form or produce the ***thiol*** ester composition.

As another embodiment of the present invention, a process to produce the ***thiol*** ester composition is advantageously provided. In this embodiment, the process includes contacting a composition

comprising a polyol with a composition comprising a ***thiol*** containing carboxylic acid composition and reacting the polyol and ***thiol*** containing carboxylic acid composition to form the ***thiol*** ester composition.

DETD In some embodiments of the present invention that include producing

thiol ester compositions, the unsaturated ester composition is a natural source oil. In an aspect, the unsaturated ester composition is soybean oil or alternatively castor oil. Other suitable types of unsaturated ester compositions are described herein and can be used in

the processes for producing the ***thiol*** ester compositions.

DETD ***Thiol*** Esters from Unsaturated Esters

DETD As an embodiment of the present invention, the ***thiol*** esters

described herein can be produced by a process comprising contacting

hydrogen sulfide and an unsaturated ester composition and reacting

hydrogen sulfide and the unsaturated ester composition to form the

thiol ester composition. In one embodiment, the unsaturated

ester composition includes unsaturated esters having an average of at

least 1.5 ester groups and an average of at least 1.5 carbon-carbon

double bonds per unsaturated ester molecule. In this embodiment, the

thiol ester composition includes ***thiol*** ester molecules

having a molar ratio of cyclic sulfides to ***thiol*** groups of

less than 1.5.

DETD The processes for producing the ***thiol*** ester composition can

be applied to any of the unsaturated esters described herein and used to

produce any of the ***thiol*** esters described herein. The process

for producing the ***thiol*** ester composition can also

include any additional process steps or process conditions described herein.

DETD The hydrogen sulfide to molar equivalents of unsaturated ester carbon-carbon double bonds molar ratio utilized in the process to produce the ***thiol*** ester composition can be any molar ratio that produces the desired ***thiol*** ester. The molar equivalents of unsaturated ester carbon-carbon double bonds is calculated by the equation: $\frac{UES\ GMW}{UES\ Mass} \times \frac{UES\ C.dbd.C}{UES\ C.dbd.C}$ In this equation, UES GMW is the average gram molecular weight of the unsaturated ester, UES Mass is the mass of the feedstock unsaturated ester, and UES C.dbd.C is the average number of double bonds per unsaturated ester molecule. In some embodiments, the ***thiol*** ester molecules have a molar ratio of the hydrogen sulfide to the unsaturated ester carbon-carbon double bonds of greater than 2. In other embodiments, the hydrogen sulfide to unsaturated ester carbon-carbon double bonds molar ratio is greater than 5; alternatively, greater than 10; alternatively, greater than 15; or alternatively, greater than 20. In other embodiments, the hydrogen sulfide to unsaturated ester carbon-carbon double bonds molar ratio can be from 2 to 500; alternatively, from 5 to 200; alternatively, from 10 to 100; or alternatively, from 100 to 200.

DETD When a continuous reactor is used, a feed unsaturated ester weight hourly space velocity ranging from 0.1 to 5 can be used to produce the desired ***thiol*** ester. Alternatively, the feed unsaturated ester weight hourly space velocity ranges between 0.1 to 5; alternatively, from 0.1 to 2. Alternatively, the feed unsaturated ester weight hourly space velocity is 0.1; alternatively, the feed unsaturated ester weight hourly space velocity is 0.25; or alternatively, the feed unsaturated ester weight hourly space velocity is 2.

DETD The time required for the reaction of the unsaturated ester and hydrogen sulfide can be any time required to form the described ***thiol*** ester. Generally, the time required for the reaction of the unsaturated ester and hydrogen sulfide is at least 5 minutes. In some embodiments, the time required for the reaction of the unsaturated ester and hydrogen sulfide ranges from 5 minutes to 72 hours; alternatively, from 10 minutes to 48 hours; or alternatively, from 15 minutes to 36 hours.

DETD In embodiments, the process to produce the ***thiol*** ester further comprises a step to remove excess or residual hydrogen sulfide after reacting the hydrogen sulfide and the unsaturated ester composition. In some embodiments, the ***thiol*** ester is vacuum stripped. In some embodiments, the ***thiol*** ester is vacuum stripped at a temperature ranging between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the ***thiol*** ester is sparged with an inert gas to remove hydrogen sulfide. In some embodiments, the ***thiol*** ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In some aspects, the inert gas is nitrogen. Generally, the stripped or sparged ***thiol*** ester comprises less than 0.1 weight percent hydrogen sulfide. In other embodiments, the stripped or sparged ***thiol*** ester comprises less than 0.05 weight percent sulfur; alternatively, less than 0.025 weight percent hydrogen sulfide; or alternatively, less than 0.01 weight percent hydrogen sulfide.

DETD The reaction between the unsaturated ester and hydrogen sulfide can be performed at any temperature capable of forming the ***thiol*** ester. In some embodiments, the unsaturated ester and hydrogen sulfide can be reacted at a temperature greater than -20.degree. C. In other embodiments, the unsaturated ester and hydrogen sulfide can be reacted at a temperature greater than 0.degree. C.; alternatively, greater than 20.degree. C.; alternatively, greater than 50.degree. C.; alternatively, greater than 80.degree. C.; or alternatively, greater than 100.degree. C. In yet other embodiments, the unsaturated ester and hydrogen sulfide can be reacted at a temperature from -20.degree. C. to 200.degree. C.; alternatively, from 120.degree. C. to 240.degree. C.; alternatively, from 170.degree. C. to 210.degree. C.; alternatively, from 185.degree. C. to 195.degree. C.; alternatively, from 20.degree. C. to 200.degree. C.; alternatively, from 20.degree. C. to 170.degree. C.; or alternatively, from 80.degree. C. to 140.degree. C.

DETD ***Thiol*** esters having a low cyclic sulfide content can be produced using the disclosed process. In an aspect, the process

for producing the ***thiol*** ester forms or produces a
 thiol ester having a molar ratio of cyclic sulfide to ***thiol***
 groups of less than 1.5. Additional cyclic sulfide to ***thiol***
 groups molar ratios are disclosed herein.
 DETD In addition to lower cyclic sulfide content, ***thiol***
 esters having a low carbon-carbon double bond to ***thiol*** group
 molar ratio can also be produced using the disclosed process. In an
 aspect, the process described herein produces the ***thiol*** ester
 having a carbon-carbon double bond to ***thiol*** group molar ratio of
 less than 1.5. Additional carbon-carbon double bond to ***thiol***
 group molar ratios are disclosed herein.
 DETD In some aspects, the process described herein produces the
 5 weight ***thiol*** ester molecules having an average of greater than
 percent ***thiol*** sulfur. Additional ***thiol*** sulfur
 contents are disclosed herein. In other aspects, the process for
 producing a ***thiol*** ester forms a ***thiol*** ester
 having greater than 40 percent of the ***thiol*** ester total side
 chains include sulfur. Other percentages of the ***thiol*** ester
 total side chains that include sulfur are disclosed herein.
 DETD In some embodiments, the process for producing a ***thiol***
 ester composition includes contacting an unsaturated ester and hydrogen
 sulfide and reacting the unsaturated ester and the hydrogen
 sulfide to form a ***thiol*** ester. The ***thiol*** ester comprises
 thiol ester molecules that have a ratio of cyclic
 sulfide to ***thiol*** groups of less than 1.5.
 DETD ***Thiol*** Ester from a Polyol and a ***Thiol***
 Containing Carboxylic Acid Derivative
 DETD As another embodiment of the present invention, another process
 to produce the ***thiol*** ester composition is advantageously
 provided. In this embodiment, the process includes the steps of
 contacting a composition comprising a polyol with a composition
 comprising a ***thiol*** containing carboxylic acid and/or
 thiol containing carboxylic acid derivative and
 reacting the polyol and ***thiol*** containing carboxylic acid and/or
 thiol containing carboxylic acid derivative to produce
 the ***thiol*** ester composition. This process can be applied to
 any polyol, ***thiol*** containing carboxylic acid, or
 thiol

containing carboxylic acid derivative described herein. The process for producing the ***thiol*** ester composition can also include any additional process steps or process conditions described herein. Additionally, the process for producing the ***thiol*** ester composition can form any ***thiol*** ester described herein.

DETD In some embodiments, the ***thiol*** ester composition includes ***thiol*** ester molecules that have an average of at least 1.5 ester groups and an average of at least 1.5 ***thiol*** groups per ***thiol*** ester molecule.

DETD The polyol used to produce the ***thiol*** ester by contacting a polyol and a ***thiol*** carboxylic acid and/or ***thiol*** carboxylic acid equivalent (for example a ***thiol*** carboxylic acid methyl ester) can be any polyol or mixture of polyols that can produce the described ***thiol*** containing ester.

DETD In one aspect, the polyol used to produce the ***thiol*** ester can comprise from 2 to 20 carbon atoms. In other embodiments, the polyol comprises from 2 to 10 carbon atoms; alternatively from 2 to 7 carbon atoms; alternatively from 2 to 5 carbon atoms. In further embodiments, the polyol may be a mixture of polyols having an average of 2 to 20 carbon atoms; alternatively, an average of from 2 to 10 carbon atoms; alternatively, an average of 2 to 7 carbon atoms; alternatively an average of 2 to 5 carbon atoms.

DETD In another aspect, the polyol used to produce the ***thiol*** ester can have any number of hydroxy groups needed to produce the ***thiol*** ester as described herein. In some embodiments, the polyol has 2 hydroxy groups; alternatively 3 hydroxy groups; alternatively, 4 hydroxy groups; alternatively, 5 hydroxy groups; or alternatively, 6 hydroxy groups. In other embodiments, the polyol comprises at least 2 hydroxy groups; alternatively at least 3 hydroxy groups; alternatively, at least 4 hydroxy groups; or alternatively, at least 5 hydroxy groups; alternatively, at least 6 hydroxy groups. In yet other embodiments, the polyol comprises from 2 to 8 hydroxy groups; alternatively, from 2 to 4 hydroxy groups; or alternatively from 4 to 8 hydroxy groups.

DETD In further aspects, the polyol used to produce the ***thiol*** ester is a mixture of polyols. In an embodiment, the mixture of polyols has an average of at least 1.5 hydroxy groups per polyol molecule. In

other embodiments, the mixture of polyols has an average of at least 2 hydroxy groups per polyol molecule; alternatively, an average of at least 2.5 hydroxy groups per polyol molecule; alternatively, an average of at least 3.0 hydroxy groups per polyol molecule; or alternatively, an average of at least 4 hydroxy groups per polyol molecule. In yet another embodiment, the mixture of polyols has an average of 1.5 to 8 hydroxy groups per polyol molecule; alternatively, an average of 2 to 6 hydroxy groups per polyol molecule; alternatively, an average of 2.5 to 5 hydroxy groups per polyol molecule; alternatively, an average of 3 to 4 hydroxy groups per polyol molecule; alternatively, an average of 2.5 to 3.5 hydroxy groups per polyol molecule; or alternatively, an average of 2.5 to 4.5 hydroxy groups per polyol molecule.

DETD In yet another aspect, the polyol or mixture of polyols used to produce the ***thiol*** ester has a molecular weight or average molecular weight less than 500. In other embodiments, the polyol or mixture of polyols have a molecular weight or average molecular weight less than 300; alternatively less than 200; alternatively, less than 150; or alternatively, less than 100.

DETD The ***thiol*** carboxylic acid and/or ***thiol*** carboxylic acid equivalent used to produce the ***thiol*** ester by contacting a polyol and a ***thiol*** carboxylic acid and/or ***thiol*** carboxylic acid equivalent can be any ***thiol*** carboxylic acid mixture comprising ***thiol*** carboxylic acids, ***thiol*** carboxylic acid equivalent or mixture comprising ***thiol*** carboxylic acid equivalents that can produce the described ***thiol*** containing ester. When talking about the characteristics ***thiol*** carboxylic acid equivalent or ***thiol*** carboxylic acid equivalents, properties such as number of carbon atoms, average number of carbon atom, molecular weight or average molecular weight, number of ***thiol*** group, and average number of ***thiol*** groups, one will understand these properties will apply to the portion of the ***thiol*** carboxylic acid equivalent which adds to the polyol to form the ***thiol*** ester.

DETD In an aspect, the ***thiol*** carboxylic acid and/or
thiol carboxylic acid equivalent used to produce the ***thiol***
ester comprises from 2 to 28 carbon atoms. In an embodiment, the
thiol carboxylic acid and/or ***thiol*** carboxylic acid equivalent
comprises from 4 to 26 carbon atoms; alternatively, from 8 to 24
carbon atoms; alternatively, from 12 to 24 carbon atoms; or
alternatively, from 14 to 20 carbon atoms. In other embodiments, a mixture comprising
thiol carboxylic acid and/or mixture comprising
thiol carboxylic acid equivalents has an average of 2 to 28 carbon
atoms per carboxylic acid and/or carboxylic acid equivalent; alternatively,
from 4 to 26 carbon atoms per carboxylic acid and/or carboxylic acid
equivalent; alternatively, from 8 to 24 carbon atoms per
carboxylic acid and/or carboxylic acid equivalent; alternatively, from 12 to 24
carbon atoms per carboxylic acid and/or carboxylic acid equivalent; or
alternatively, from 14 to 20 carbon atoms per carboxylic acid
and/or carboxylic acid equivalent.
DETD In another aspect, the ***thiol*** carboxylic acid and/or
thiol carboxylic acid equivalent used to produce the
thiol ester has at least 1 ***thiol*** group;
alternatively 2 ***thiol*** groups. In some embodiments, a mixture
comprising ***thiol*** carboxylic acid and/or mixture comprising
thiol carboxylic acid equivalents has an average of from 0.5 to 3
thiol groups per carboxylic acid and/or carboxylic acid
equivalent; alternatively, an average of from 1 to 2
thiol groups per carboxylic acid and/or carboxylic acid equivalent.
DETD In another aspect, the ***thiol*** carboxylic acid and/or
thiol carboxylic acid equivalent used to produce the
thiol ester has a molecular weight greater than 100;
alternatively greater than 180; alternatively greater than 240;
or alternatively greater than 260. In other embodiments, the
thiol carboxylic acid and/or ***thiol*** carboxylic acid equivalent
has a molecular weight from 100 to 500; alternatively, from 120 to 420;
alternatively, from 180 to 420; alternatively, from 240 to 420; a
mixture or alternatively, from 260 to 360. In some embodiments, a
mixture comprising ***thiol*** carboxylic acid and/or mixture
comprising ***thiol*** carboxylic acid equivalents has an
average molecular weight greater than 100 per carboxylic acid and/or
carboxylic acid equivalent; alternatively greater than 180 per carboxylic
acid and/or carboxylic acid equivalent; alternatively greater than 240

per carboxylic acid and/or carboxylic acid equivalent; or
alternatively
greater than 260 per carboxylic acid and/or carboxylic acid
equivalent.
In yet other embodiments, the mixture comprising of ***thiol***
carboxylic acid and/or mixture comprising ***thiol***
carboxylic acid equivalents has an average molecular weight from 100 to 500
per carboxylic acid and/or carboxylic acid equivalent; alternatively,
from 120 to 420 per carboxylic acid and/or carboxylic acid equivalent;
alternatively, from 180 to 420 per carboxylic acid and/or
carboxylic acid equivalent; alternatively, from 240 to 420 per carboxylic
acid and/or carboxylic acid equivalent; a mixture or alternatively,
from 260 to 360 per carboxylic acid and/or carboxylic acid equivalent.
DETD In some aspects, the reaction between the polyol and the
thiol containing carboxylic acid and/or ***thiol*** containing
carboxylic acid derivative occurs in the presence of a solvent. In other
aspects the reaction between the polyol and the ***thiol***
containing carboxylic acid and/or ***thiol*** containing carboxylic acid
derivative occurs in the substantial absence of a solvent. In
aspects wherein the reaction between the polyol and the ***thiol***
containing carboxylic acid and/or ***thiol*** containing
carboxylic acid derivative occurs in the presence of a solvent, the solvent
is selected from the group consisting of an aliphatic hydrocarbon,
an ether, an aromatic compound, or any combination thereof.
Generally, the solvent, regardless of its chemical class, can include from 1 to
20 carbon atoms; or alternatively, from 3 to 10 carbon atoms. When
the solvent includes the aliphatic hydrocarbon, the aliphatic
hydrocarbon is butane, isobutane, pentane, hexane, heptane, octane, or any
mixture thereof. When the solvent includes the aromatic compound, the
aromatic compound is benzene, toluene, xylene, ethylbenzene, or any
mixture thereof. When the solvent includes the ether, the ether is
diethyl ether, dipropyl ether, tetrahydrofuran, and any mixture thereof.
DETD When a solvent is used for the reaction between the polyol and the
the ***thiol*** containing carboxylic acid and/or ***thiol***
containing carboxylic acid derivative, the quantity of solvent
can be

any amount that facilitates the reaction. In some embodiments, the mass of the solvent is less than 30 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative. In other embodiments, the mass of the solvent is less than 20 times the mass of the unsaturated ester oil; alternatively, less than 15 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative; alternatively, less than 10 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative; or alternatively, less than 5 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative. In other embodiments, the mass of the solvent is from 2 times to 20 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative; alternatively, from 3 times to 15 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative, or alternatively, from 5 times to 10 times the mass of the ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative.

DETD The equivalent of ***thiol*** containing carboxylic acid and/or ***thiol*** containing carboxylic acid derivative carboxylic acid groups to equivalents of polyol hydroxy groups molar ratio (hereinafter "carboxylic acid group to polyol hydroxy group molar ratio") utilized in the process to produce the ***thiol*** ester composition can be any carboxylic acid group to polyol hydroxy group molar ratio that produces the desired ***thiol*** ester composition. In some embodiments, the carboxylic acid group to polyol hydroxy group molar ratio is greater than 0.4. In other embodiments, the carboxylic acid group to polyol hydroxy group molar ratio is greater than 0.6; alternatively, greater than 0.8; alternatively, greater than 1; or alternatively, greater than 1.1. In other embodiments, the carboxylic acid group to polyol hydroxy group molar ratio can range from 0.4 to 1.3; alternatively, from 0.6 to 1.2, or alternatively, from 0.8 to 1.1.

DETD In some aspects, the reaction between the polyol and the
thiol
containing carboxylic acid and/or ***thiol*** containing
carboxylic
acid derivative is catalyzed. In some embodiments, the catalyst
is a
mineral acid, such as sulfuric or phosphoric acid. In other
embodiments,
the catalyst is an organic acid. In embodiments, for example, the
organic acid is methane sulfonic acid or toluene sulfonic acid.

Other suitable types of catalyst will be apparent to those of skill in
the art
and are to be considered within the scope of the present
invention.

DETD The reaction of the polyol and the ***thiol*** containing
carboxylic acid and/or ***thiol*** containing carboxylic acid
derivative can occur in a batch reactor or a continuous reactor,
as
described herein. The reaction between the polyol and the
thiol
containing carboxylic acid and/or ***thiol*** containing
carboxylic
acid derivative can be performed at any temperature capable of
forming
the ***thiol*** ester. In some embodiments, the polyol and
the
thiol containing carboxylic acid and/or ***thiol***
containing carboxylic acid derivative can be reacted at a
temperature
greater than 20.degree. C. In other embodiments, the polyol and
the
thiol containing carboxylic acid and/or ***thiol***
containing carboxylic acid derivative can be reacted at a
temperature
greater than 50.degree. C.; alternatively, greater than
75.degree. C.;
or alternatively, greater than 100.degree. C. In yet other
embodiments,
the polyol and the ***thiol*** containing carboxylic acid
and/or
thiol containing carboxylic acid derivative can be
reacted at a
temperature from 20.degree. C. to 250.degree. C.; alternatively,
from
50.degree. C. to 200.degree. C.; alternatively, from 75.degree.
C. to
175.degree. C.; or alternatively, from 100.degree. C. to
150.degree. C.

DETD The time required for the reaction of the polyol and the
thiol
containing carboxylic acid and/or ***thiol*** containing
carboxylic
acid derivative can be any time required to form the described
thiol ester oil. Generally, the reaction time of the
polyol and
the ***thiol*** containing carboxylic acid and/or
thiol
containing carboxylic acid derivative is at least 5 minutes. In
some

embodiments, the reaction time is at least 30 minutes;
alternatively, at least 1 hour; or alternatively, at least 2 hours. In yet other
embodiments, the reaction time ranges from 5 minutes to 72 hours;
alternatively, from 30 minutes to 48 hours; alternatively, from 1
hour minutes to 36 hours; or alternatively, from 2 hours and 24 hours.
DETD When a continuous reactor is used, a feed polyol weight
unsaturated ester weight hourly space velocity ranging from 0.1 to 5 can be
used to produce the desired ***thiol*** ester. Alternatively, the
feed polyol weight hourly space velocity ranges between 0.1 to 5;
alternatively, from 0.1 to 2. Alternatively, the feed polyol
ester weight hourly space velocity is 0.1; alternatively, the feed
polyol weight hourly space velocity is 0.25; or alternatively, the feed
polyol weight hourly space velocity is 2.
DETD The reaction between the polyol and the ***thiol***
containing carboxylic acid and/or ***thiol*** containing carboxylic acid
derivative can be performed at any reaction pressure that
maintains the polyol and the ***thiol*** containing carboxylic acid and/or
thiol containing carboxylic acid derivative in a liquid
state. In some embodiments, the reaction between the polyol and the
thiol containing carboxylic acid and/or ***thiol***
containing carboxylic acid derivative is performed at a pressure
ranging from 0 psia to 2000 psia. In other embodiments, the reaction
pressure ranges from 0 psia to 1000 psia; alternatively, from 0 psia and
500 psia; or alternatively, 0 psia to 300 psia.
DETD In some embodiments, the process to produce the ***thiol***
ester by reacting a polyol and the ***thiol*** containing
carboxylic acid and/or ***thiol*** containing carboxylic acid derivative can
further include a step to remove excess or residual polyol, ***thiol***
containing carboxylic acid, and/or ***thiol*** containing
carboxylic acid derivative once the polyol has reacted with the
thiol containing carboxylic acid or ***thiol*** containing
carboxylic acid derivative. In some embodiments, the ***thiol*** ester is
vacuum stripped. In some embodiments, the ***thiol*** ester is
vacuum stripped at a temperature ranging between 25.degree. C. and
250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In
other embodiments, the ***thiol*** ester is sparged with an inert

gas to
 remove excess polyol, ***thiol*** containing carboxylic acid,
 and/or
 thiol containing carboxylic acid derivative. In some
 embodiments, the ***thiol*** ester is sparged with an inert
 gas at a
 temperature between 25.degree. C. and 250.degree. C.; or
 alternatively,
 between 50.degree. C. and 200.degree. C. In some aspects, the
 inert gas
 is nitrogen. Generally, the stripped or sparged ***thiol***
 ester
 comprises less than 5 excess polyol, ***thiol*** containing
 carboxylic acid, or ***thiol*** containing carboxylic acid
 derivative. In other embodiments, the stripped or sparged
 thiol
 ester comprises less than 2 weight percent excess polyol,
 thiol
 containing carboxylic acid, and/or ***thiol*** containing
 carboxylic
 acid derivative; alternatively, less than 1 weight percent excess
 polyol, ***thiol*** containing carboxylic acid, and/or
 thiol
 containing carboxylic acid derivative; or alternatively, less
 than 0.5
 weight percent excess polyol, ***thiol*** containing
 carboxylic
 acid, and/or ***thiol*** containing carboxylic acid
 derivative.
 DETD Process for Making Hydroxy ***Thiol*** Ester Composition
 DETD The present invention advantageously provides processes for
 producing a
 hydroxy ***thiol*** ester as embodiments of the present
 invention.
 As an embodiment, the present invention includes a process to
 produce
 the hydroxy ***thiol*** ester. The process comprises the
 steps of
 contacting hydrogen sulfide and an epoxidized unsaturated ester
 composition and reacting the hydrogen sulfide and the epoxidized
 unsaturated ester to form the hydroxy ***thiol*** ester. As
 another
 embodiment of the present invention, another process to produce
 the
 hydroxy ***thiol*** ester is provided. In this embodiment,
 the
 process comprises the steps of contacting a composition
 comprising a
 polyol with a composition comprising an hydroxy ***thiol***
 containing carboxylic acid or an hydroxy ***thiol***
 containing
 carboxylic acid derivative and reacting the polyol and the
 hydroxy
 thiol containing carboxylic acid or the hydroxy
 thiol
 containing carboxylic acid derivative to form the hydroxy
 thiol
 ester.
 DETD Hydroxy ***Thiol*** Ester from Hydrogen Sulfide and an
 Epoxidized

Unsaturated Ester Composition

DETD As an embodiment of the present invention, the hydroxy
 thiol
 ester composition is produced by a process comprising the steps
 of
 contacting hydrogen sulfide and an epoxidized unsaturated ester
 composition and reacting the hydrogen sulfide and the epoxidized
 unsaturated ester to produce the hydroxy ***thiol*** ester
 composition.

DETD In some embodiments, the epoxidized unsaturated ester
 composition
 includes epoxidized unsaturated esters that have an average of at
 least
 1 ester groups and an average of at least 1 ***epoxide***
 groups per
 epoxidized unsaturated ester molecule.

DETD The process for producing or preparing the hydroxy ***thiol***
 ester composition can be applied to any of the epoxidized
 unsaturated
 esters described herein and used to produce any hydroxy
 thiol
 ester described herein. The process for producing the hydroxy
 thiol ester can also include any additional process
 steps or
 process conditions as described herein. Additionally, the process
 for
 producing the hydroxy ***thiol*** ester can form any hydroxy
 thiol ester described herein.

DETD In some aspects, the hydroxy ***thiol*** ester is produced
 by
 contacting hydrogen sulfide with the epoxidized natural source
 oil under
 the reaction conditions to form the hydroxy ***thiol*** ester
 in the
 presence of an optional catalyst. In some embodiments, the
 catalyst can
 be a heterogeneous catalyst or a homogeneous catalyst. Examples
 of
 suitable catalysts are described herein. Additional types of
 suitable
 catalysts will be apparent to those of skill in the art and are
 to be
 considered within the scope of the present invention.

DETD The hydrogen sulfide to molar equivalents of ***epoxide***
 groups
 in the epoxidized unsaturated ester (hereinafter "hydrogen
 sulfide to
 epoxide group molar ratio") utilized in the process to
 produce
 the hydroxy ***thiol*** ester can be any hydrogen sulfide to
 epoxide group molar ratio that produces the desired
 hydroxy
 thiol ester. The molar equivalents of epoxidized
 unsaturated
 ester epoxidized groups can be calculated by the equation:

##EQU2##

In this equation, EUES GMW is the average gram molecular weight
 of the
 epoxidized unsaturated ester, EUES Mass is the mass of the
 epoxidized

unsaturated ester, and EUES ***Epoxide*** is the average number of ***epoxide*** groups per epoxidized unsaturated ester molecule. In some embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio is greater than 0.2. In other embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio is greater than 0.5; alternatively, greater than 1; or alternatively, greater than 2. In other embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio ranges from 0.2 to 5; alternatively, from 0.5 to 4; or alternatively, from 0.75 to 3. In some embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio is greater than 2. In other embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio is greater than 5; alternatively, greater than 10; alternatively, greater than 15; or alternatively, greater than 20. In other embodiments, the hydrogen sulfide to ***epoxide*** group molar ratio can be from 0.2 to 500; alternatively, from 0.5 to 400; alternatively, from 1 to 300; alternatively, from 2 to 250; alternatively, 5 to 200; or alternatively, from 10 to 100.

DETD The time required for the reaction of the epoxidized unsaturated ester and hydrogen sulfide can be any time required to form the described hydroxy ***thiol*** ester. Generally, the time required for the reaction of the epoxidized unsaturated ester and hydrogen sulfide is at least 15 minutes. In some embodiments, the time required for the reaction of the unsaturated ester and hydrogen sulfide ranges from 15 minutes to 72 hours; alternatively, from 30 minutes to 48 hours; alternatively, from 45 minutes to 36 hours.

DETD In some embodiments, the hydroxy ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules that have an average of greater than 2.5 weight percent ***thiol*** sulfur. In some embodiments, the hydroxy ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules that have an average of greater than 5 weight percent ***thiol*** sulfur. Alternatively, in some embodiments, the hydroxy ***thiol*** ester molecules have an average ranging from 8 to 10 weight percent ***thiol*** sulfur.

DETD In other aspects, the process producing the hydroxy ***thiol*** ester composition includes producing hydroxy ***thiol***

ester molecules having an average of greater than 40 percent of the sulfide-containing ester total side chains comprise a sulfide group. Additional embodiments wherein the hydroxy ***thiol*** ester comprises a percentage of sulfide-containing ester total side chains are described herein.

DETD In embodiments, the process to produce the hydroxy ***thiol*** ester further comprises a step to remove residual hydrogen sulfide after reacting the hydrogen sulfide and the epoxidized unsaturated ester composition. In some embodiments, the hydroxy ***thiol*** ester is vacuum stripped. In some embodiments, the hydroxy ***thiol*** ester is vacuum stripped at a temperature ranging between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the hydroxy ***thiol*** ester is sparged with an inert gas to remove hydrogen sulfide. In some embodiments, the hydroxy ***thiol*** ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In some aspects, the inert gas is nitrogen. Generally, the stripped or sparged hydroxy ***thiol*** ester comprises less than 0.1 weight percent hydrogen sulfide. In other embodiments, the stripped or sparged hydroxy ***thiol*** ester comprises less than 0.05 weight percent hydrogen sulfide; alternatively, less than 0.025 weight percent hydrogen sulfide; or alternatively, less than 0.01 weight percent hydrogen sulfide.

DETD The reaction between the hydrogen sulfide and the epoxidized unsaturated ester can be performed at any temperature capable of forming the hydroxy ***thiol*** ester. In some embodiments, the epoxidized unsaturated ester and hydrogen sulfide can be reacted at a reaction temperature greater than -20.degree. C. In other embodiments, the reaction temperature is greater than 0.degree. C.; alternatively, greater than 20.degree. C.; alternatively, greater than 50.degree. C.; or alternatively, greater than 80.degree. C. In yet other embodiments, the reaction temperature ranges from -20.degree. C. to 200.degree. C.; alternatively, from 20.degree. C. to 170.degree. C.; or alternatively, from 80.degree. C. to 140.degree. C.

DETD In another aspect, the process to produce a hydroxy

thiol
 ester produces a hydroxy ***thiol*** ester having an
 epoxide
 group to ***thiol*** group molar ratio less than 3.3. In
 another
 aspect, the process to produce a hydroxy ***thiol*** ester
 produces
 a hydroxy ***thiol*** ester having an ***epoxide*** group
 to
 thiol group molar ratio less than 2. Other hydroxy
 thiol
 ester ***epoxide*** group to ***thiol*** group molar
 ratios are
 described herein. Alternatively, the hydroxy ***thiol***
 ester
 epoxide group to ***thiol*** group molar ratio can
 be less
 than 1.5; alternatively, less than 1.0; alternatively, less than
 0.5;
 alternatively, less than 0.25; or alternatively, less than 0.1.
 In other
 embodiments, the hydroxy ***thiol*** ester can be
 substantially free
 of ***epoxide*** groups.
 DETD In another aspect, the process to produce hydroxy ***thiol***
 ester
 produces a hydroxy ***thiol*** ester wherein at least 20
 percent of
 the side chains comprise an .alpha.-hydroxy ***thiol***
 group. Other
 hydroxy ***thiol*** ester embodiments wherein the hydroxy
 thiol ester contains a percentage of side chains
 comprising
 .alpha.-hydroxy ***thiol*** groups are described herein.
 DETD Hydroxy ***Thiol*** Ester from a Polyol and a Hydroxy
 Thiol
 Containing Carboxylic Acid Derivative
 DETD As another embodiment of the present invention, another process
 to
 prepare the hydroxy ***thiol*** ester is advantageously
 provided. In
 this embodiment, the process includes the steps of contacting a
 composition comprising a polyol with a composition comprising a
 hydroxy
 thiol containing carboxylic acid and/or ***thiol***
 containing carboxylic acid derivative and reacting the polyol and
 hydroxy ***thiol*** containing carboxylic acid and/or hydroxy
 thiol containing carboxylic acid to form a hydroxy
 thiol
 ester composition. This process can be applied to any polyol, any
 hydroxy ***thiol*** containing carboxylic acid, or any
 thiol
 containing carboxylic acid derivative described herein. The
 process for
 producing the hydroxy ***thiol*** ester composition can also
 include
 any additional process steps or process conditions described
 herein.
 Additionally, the process for producing the hydroxy ***thiol***
 ester composition can form any ***thiol*** ester described

herein.

DETD In some embodiments, the hydroxy ***thiol*** ester composition includes hydroxy ***thiol*** ester molecules that have an average of at least 1 ester groups per hydroxy ***thiol*** ester molecule and an average of at least 1 .alpha.-hydroxy ***thiol*** groups per hydroxy ***thiol*** ester molecule.

DETD The polyol used to produce the hydroxy ***thiol*** ester by contacting a polyol and a hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent (for example a hydroxy ***thiol*** carboxylic acid methyl ester) can be any polyol or mixture of polyols that can produce the described ***thiol*** containing ester.

DETD In one aspect, the polyol used to produce the hydroxy ***thiol*** ester can comprise from 2 to 20 carbon atoms. In other embodiments, the polyol comprises from 2 to 10 carbon atoms; alternatively from 2 to 7 carbon atoms; alternatively from 2 to 5 carbon atoms. In further embodiments, the polyol may be a mixture of polyols having an average of 2 to 20 carbon atoms; alternatively, an average of from 2 to 10 carbon atoms; alternatively, an average of 2 to 7 carbon atoms; alternatively an average of 2 to 5 carbon atoms.

DETD In another aspect, the polyol used to produce the hydroxy ***thiol*** ester can have any number of hydroxy groups needed to produce the hydroxy ***thiol*** ester as described herein. In some embodiments, the polyol has 2 hydroxy groups; alternatively 3 hydroxy groups; alternatively, 4 hydroxy groups; alternatively, 5 hydroxy groups; or alternatively, 6 hydroxy groups. In other embodiments, the polyol comprises at least 2 hydroxy groups; alternatively at least 3 hydroxy groups; alternatively, at least 4 hydroxy groups; or alternatively, at least 5 hydroxy groups; at least 6 hydroxy groups. In yet other embodiments, the polyol comprises from 2 to 8 hydroxy groups; alternatively, from 2 to 4 hydroxy groups; or alternatively from 4 to 8 hydroxy groups.

DETD In further aspects, the polyol used to produce the hydroxy ***thiol*** ester is a mixture of polyols. In an embodiment, the mixture of polyols has an average of at least 1.5 hydroxy groups per polyol molecule. In other embodiments, the mixture of polyols has an average of at least 2 hydroxy groups per polyol molecule; alternatively,

an average of at least 2.5 hydroxy groups per polyol molecule;
alternatively, an average of at least 3.0 hydroxy groups per
polyol molecule; or alternatively, an average of at least 4 hydroxy
groups per polyol molecule. In yet another embodiment, the mixture of
polyols has an average of 1.5 to 8 hydroxy groups per polyol molecule;
alternatively, an average of 2 to 6 hydroxy groups per polyol
molecule; alternatively, an average of 2.5 to 5 hydroxy groups per polyol
molecule; alternatively, an average of 3 to 4 hydroxy groups per
polyol molecule; alternatively, an average of 2.5 to 3.5 hydroxy groups
per polyol molecule; or alternatively, an average of 2.5 to 4.5
hydroxy groups per polyol molecule.

DETD In yet another aspect, the polyol or mixture of polyols used to
produce the hydroxy ***thiol*** ester has a molecular weight or
average molecular weight less than 500. In other embodiments, the polyol
or mixture of polyols have a molecular weight or average molecular
weight less than 300; alternatively less than 200; alternatively, less
than 150; or alternatively, less than 100.

DETD The hydroxy ***thiol*** carboxylic acid and/or hydroxy
thiol carboxylic acid equivalent used to produce the
hydroxy ***thiol*** ester by contacting a polyol and a hydroxy
thiol carboxylic acid and/or hydroxy ***thiol*** carboxylic acid
equivalent can be any hydroxy ***thiol*** carboxylic acid
mixture comprising hydroxy ***thiol*** carboxylic acids, hydroxy
thiol carboxylic acid equivalent or mixture comprising
hydroxy ***thiol*** carboxylic acid equivalents that can produce the
described hydroxy ***thiol*** containing ester. When talking about the
characteristics hydroxy ***thiol*** carboxylic acid
equivalent or hydroxy ***thiol*** carboxylic acid equivalents, properties
such as number of carbon atoms, average number of carbon atom, molecular
weight or average molecular weight, number of ***thiol*** group, and
average number of ***thiol*** groups, one will understand the
these properties will apply to the portion of the ***thiol***
carboxylic acid equivalent which adds to the polyol to form the
thiol ester.

DETD In an aspect, the hydroxy ***thiol*** carboxylic acid and/or
hydroxy ***thiol*** carboxylic acid equivalent used to
produce the

thiol ester comprises from 2 to 28 carbon atoms. In an embodiment, the hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalents comprises from 4 to 26 carbon atoms; alternatively, from 8 to 24 carbon atoms; alternatively, from 12 to 24 carbon atoms; or alternatively, from 14 to 20 carbon atoms. In other embodiments, a mixture comprising hydroxy ***thiol*** carboxylic acids and/or mixture comprising hydroxy ***thiol*** carboxylic acid equivalents has an average of 2 to 28 carbon atoms per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 4 to 26 carbon per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 8 to 24 carbon atoms per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 12 to 24 carbon atoms per carboxylic acid and/or carboxylic acid equivalent; or alternatively, from 14 to 20 carbon atoms per carboxylic acid and/or carboxylic acid equivalent.

DETD In another aspect, the hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent used to produce the ***thiol*** ester has at least 1 ***thiol*** group, alternatively 2 ***thiol*** groups. In some embodiments, a mixture comprising hydroxy ***thiol*** carboxylic acids and/or mixture comprising hydroxy ***thiol*** carboxylic acid equivalents has an average of from 0.5 to 3 ***thiol*** groups per carboxylic acid and/or carboxylic acid equivalent; alternatively, an average of from 1 to 2 ***thiol*** groups per carboxylic acid and/or carboxylic acid equivalent.

DETD In another aspect, the hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent used to produce the ***thiol*** ester has at least 1 hydroxy group; alternatively, at least 2 hydroxy groups. In some embodiments, a mixture comprising hydroxy ***thiol*** carboxylic acids and/or mixture comprising hydroxy ***thiol*** carboxylic acid equivalents has an average of from 0.5 to 3 hydroxy groups per carboxylic acid and/or carboxylic acid equivalent; alternatively, an average of from 1 to 2 hydroxy groups per carboxylic acid and/or carboxylic acid equivalent.

DETD In another aspect, the hydroxy ***thiol*** carboxylic acid

and/or hydroxy ***thiol*** carboxylic acid equivalent used to produce the hydroxy ***thiol*** ester has a molecular weight greater than 100; alternatively greater than 180; alternatively greater than 240; or alternatively greater than 260. In other embodiments, the hydroxy ***thiol*** carboxylic acid and/or hydroxy ***thiol*** carboxylic acid equivalent has a molecular weight from 100 to 500; alternatively, from 120 to 420; alternatively, from 180 to 420; alternatively, from 240 to 420; a mixture or alternatively, from 260 to 360. In some embodiments, a mixture comprising hydroxy ***thiol*** carboxylic acids and/or mixture comprising hydroxy ***thiol*** carboxylic acid equivalents has an average molecular weight greater than 100 per carboxylic acid and/or carboxylic acid equivalent; alternatively greater than 180 per carboxylic acid and/or carboxylic acid equivalent; alternatively greater than 240 per carboxylic acid and/or carboxylic acid equivalent; or alternatively greater than 260 per carboxylic acid and/or carboxylic acid equivalent. In yet other embodiments, the mixture comprising hydroxy ***thiol*** carboxylic acid and/or mixture comprising hydroxy ***thiol*** carboxylic acid equivalents has an average molecular weight from 100 to 500 per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 120 to 420 per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 180 to 420 per carboxylic acid and/or carboxylic acid equivalent; alternatively, from 240 to 420 per carboxylic acid and/or carboxylic acid equivalent; a mixture or alternatively, from 260 to 360 per carboxylic acid and/or carboxylic acid equivalent.

DETD In some aspects, the reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative occurs in the presence of a solvent. In other aspects, the reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative occurs in the substantial absence of a solvent. In aspects wherein the reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative occurs in the presence of a solvent, the solvent is selected from the group consisting of an aliphatic hydrocarbon, an ether, an aromatic compound, or any combination thereof. Generally, the

solvent, regardless of its chemical class, includes from 1 to 20 carbon atoms;
alternatively, from 3 to 10 carbon atoms. When the solvent includes the aliphatic hydrocarbon, the aliphatic hydrocarbon is butane, isobutane, pentane, hexane, heptane, octane, or any mixture thereof. When the solvent includes the aromatic compound, the aromatic compound is benzene, toluene, xylene, ethylbenzene, or any mixture thereof.

When the solvent includes the ether, the ether is diethyl ether, dipropyl ether, tetrahydrofuran, and any mixture thereof.

DETD When a solvent is used for the reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative, the quantity of solvent can be any amount that facilitates the reaction. In some embodiments, the mass of the solvent is less than 30 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative. In other embodiments, the mass of the solvent is less than 20 times the mass of the hydroxy ***thiol*** ester; alternatively, less than 15 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative; alternatively, less than 10 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative; or alternatively, less than 5 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative. In other embodiments, the mass of the solvent is from 2 times to 20 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative; alternatively, from 3 times to 15 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative; or alternatively, from 5 times to 10 times the mass of the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative.

DETD The equivalents of hydroxy ***thiol*** containing carboxylic acid derivative and/or hydroxy ***thiol*** containing carboxylic acid

derivative carboxylic acid groups to equivalents of polyol hydroxy groups molar ratio (hereinafter referred to as "carboxylic acid group to polyol hydroxy group molar ratio") utilized in the process to produce the hydroxy ***thiol*** ester can be any carboxylic acid group to polyol hydroxy group molar ratio that produces the desired hydroxy ***thiol*** ester. In some embodiments, the carboxylic acid group to polyol hydroxy group molar ratio is greater than 0.4. In other embodiments, the carboxylic acid group to polyol hydroxy group molar ratio is greater than 0.6; alternatively, greater than 0.8; alternatively, greater than 1; or alternatively, greater than 1.1. In other embodiments, the carboxylic acid group to polyol hydroxy group molar ratio ranges from 0.4 to 1.3; alternatively, from 0.6 to 1.2, or alternatively, from 0.8 to 1.1.

DETD In some aspects, the reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative is catalyzed. In some embodiments, the catalyst is a mineral acid, such as sulfuric or phosphoric acid. In other embodiments, the catalyst is an organic acid. In embodiments, for example, the organic acid is methane sulfonic acid or toluene sulfonic acid. Other suitable types of catalyst will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD The reaction of the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative can occur in a batch reactor or a continuous reactor, as described herein. The reaction between the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative can be performed at any temperature capable of forming the hydroxy ***thiol*** ester.

In some embodiments, the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative can be reacted at a temperature greater than 20.degree. C. In other embodiments, the polyol and the hydroxy ***thiol*** containing carboxylic acid and/or hydroxy ***thiol*** containing carboxylic acid derivative can be reacted at a temperature

greater than
50.degree. C.; alternatively, greater than 75.degree. C.; or
alternatively, greater than 100.degree. C. In yet other
embodiments, the
polyol and the hydroxy ***thiol*** containing carboxylic acid
and/or
hydroxy ***thiol*** containing carboxylic acid derivative can
be
reacted at a temperature from 20.degree. C. to 250.degree. C.;
alternatively, from 50.degree. C. to 200.degree. C.;
alternatively, from
75.degree. C. to 175.degree. C.; or alternatively, from
100.degree. C.
to 150.degree..

DETD The time required for the reaction of the polyol and the hydroxy
thiol containing carboxylic acid and/or hydroxy
thiol
containing carboxylic acid derivative can be any time required to
form
the described hydroxy ***thiol*** ester composition.

Generally, the
reaction time is at least 5 minutes. In some embodiments, the
reaction
time is at least 30 minutes; alternatively, at least 1 hour; or
alternatively, at least 2 hours. In yet other embodiments, the
reaction
time ranges from 5 minutes to 72 hours; alternatively, from 30
minutes
to 48 hours; alternatively, from 1 hour minutes to 36 hours; or
alternatively, from 2 hours and 24 hours.

DETD The reaction between the polyol and the hydroxy ***thiol***
containing carboxylic acid and/or hydroxy ***thiol***
containing
carboxylic acid derivative can be performed at any reaction
pressure
that maintains the polyol and the hydroxy ***thiol***
containing
carboxylic acid and/or hydroxy ***thiol*** containing
carboxylic
acid derivative in a liquid state. In some embodiments, the
reaction
pressure ranges from 0 psia to 2000 psia. In other embodiments,
the
reaction pressure ranges from 0 psia to 1000 psia; alternatively,
from 0
psia and 500 psia; or alternatively, from 0 psia to 300 psia.

DETD In some embodiments, the process to produce the hydroxy
thiol
ester composition by reacting a polyol and the hydroxy
thiol
containing carboxylic acid and/or hydroxy ***thiol***
containing
carboxylic acid derivative can further include a step to remove
excess
or residual polyol, hydroxy ***thiol*** containing carboxylic
acid,
and/or hydroxy ***thiol*** containing carboxylic acid
derivative
once the polyol has reacted with the hydroxy ***thiol***
containing

acid carboxylic acid or hydroxy ***thiol*** containing carboxylic derivative. In some embodiments, the ***thiol*** ester is vacuum stripped. In some embodiments, the hydroxy ***thiol*** ester is vacuum stripped at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the hydroxy ***thiol*** ester is sparged with an inert gas to remove excess polyol, hydroxy ***thiol*** containing carboxylic acid, and/or hydroxy ***thiol*** containing carboxylic acid derivative. In some embodiments, the hydroxy ***thiol*** ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C., or alternatively, between 50.degree. C. and 200.degree. C. In some aspects, the inert gas is nitrogen. Generally, the stripped or sparged hydroxy ***thiol*** ester oil comprises less than 5 excess polyol, hydroxy ***thiol*** containing carboxylic acid, or hydroxy ***thiol*** containing carboxylic acid derivative. In other embodiments, the stripped or sparged hydroxy ***thiol*** ester oil comprises less than 2 weight percent excess polyol, hydroxy ***thiol*** containing carboxylic acid, and/or hydroxy ***thiol*** containing carboxylic acid derivative; less than 1 weight percent excess polyol, hydroxy ***thiol*** containing carboxylic acid, and/or hydroxy ***thiol*** containing carboxylic acid derivative; or alternatively, less than 0.5 weight percent excess polyol, hydroxy ***thiol*** containing carboxylic acid, and/or hydroxy ***thiol*** containing carboxylic acid derivative.

DETD A method of making a thioacrylate containing ester composition is advantageously provided as another embodiment of the present invention. The process for producing the thioacrylate containing ester comprising contacting a ***thiol*** ester with an acrylate and converting at least one ***thiol*** group to a ***thiol*** acrylate group. The process can be applied to any of the ***thiol*** esters described herein and used to any thioacrylate ester described herein. The process for producing the thioacrylate ester can also include any additional

process steps or process conditions described herein.

DETD The acrylate compound can be any acrylate compound capable of reacting with a ***thiol*** group to form the ***thiol*** acrylate group.

In some embodiments, the acrylate compound can be an acrylic halide. In other embodiments, the acrylate compound can be an acrylic acid. In yet other embodiments, the acrylate compound can be an acrylic anhydride.

DETD In some aspects, the conversion of the ***thiol*** group to a thioacrylate group occurs in the presence of a solvent. In other aspects the conversion of the ***thiol*** group to a thioacrylate group occurs in the substantial absence of a solvent. In aspects wherein the conversion of the ***thiol*** group to a thioacrylate group occurs in the presence of a solvent, the solvent may be an aliphatic hydrocarbon, an ether, and aromatic compound. Generally, the solvent, regardless of its chemical class, includes from 1 to 20 carbon atoms; or alternatively, from 3 to 10 carbon atoms. When the solvent includes the aliphatic hydrocarbon, the aliphatic hydrocarbon is butane, isobutane, pentane, hexane, heptane, octane, or any mixture thereof. When the solvent includes the aromatic compound, the aromatic compound is benzene, toluene, xylene, ethylbenzene, or any mixture thereof.

When the solvent includes the ether, the ether is diethyl ether, dipropyl ether, tetrahydrofuran, or any mixture thereof.

DETD When a solvent is used for the conversion of the ***thiol*** group to a thioacrylate group, the quantity of solvent can be any amount that facilitates the reaction. In some embodiments, the mass of the solvent is less than 30 times the mass of the ***thiol*** ester. In other embodiments, the mass of the solvent is less than 20 times the mass of the ***thiol*** ester; alternatively, less than 15 times the mass of the ***thiol*** ester; alternatively, less than 10 times the mass of the ***thiol*** ester; or alternatively, less than 5 times the mass of the ***thiol*** ester. In other embodiments, the mass of the solvent is from 2 times to 20 times the mass of the ***thiol*** ester; alternatively, from 3 times to 15 times the mass of the ***thiol*** ester; alternatively, 4 times to 15 times the mass of the

thiol ester; or alternatively, from 5 times to 10 times
 the mass of the ***thiol*** ester.
 DETD In some aspects the conversion of the ***thiol*** group to
 the thioacrylate group occurs in the presence of a catalyst. In some
 embodiments, the catalyst is homogeneous. In some embodiments,
 the catalyst is an organic amine. Examples of suitable organic amines
 include triethylamine, tripropylamine, tributylamine, and
 pyridine. In other embodiments, the catalyst is heterogeneous. Examples of
 suitable catalysts include Amberlyst A-21 and Amberlyst A-26. Other
 suitable catalysts will be apparent to those of skill in the art and are
 to be considered within the scope of the present invention.
 DETD The conversion of the ***thiol*** group to a thioacrylate
 group can be performed at any conversion temperature that is capable of
 converting the ***thiol*** group to a thioacrylate group. In some
 embodiments, the conversion temperature is greater than -20.degree. C. In
 other embodiments, the conversion temperature is greater than 0.degree.
 C.; alternatively, greater than 20.degree. C.; alternatively, greater
 than 50.degree. C.; alternatively, greater than 80.degree. C.; or
 alternatively, greater than 100.degree. C. In yet other
 embodiments, the conversion temperature ranges from -20.degree. C. to 250.degree.
 C.; alternatively, from 20.degree. C. to 200.degree. C.; or
 alternatively, from 50.degree. C. to 150.degree. C.
 DETD The conversion time required for the conversion of the
 thiol group to a thioacrylate group can be any time required to form
 the described thioacrylate containing ester. Generally, the
 conversion time is at least 5 minutes. In some embodiments, the conversion time
 is at least 15 minutes; alternatively, at least 30 minutes;
 alternatively, at least 45 minutes; or alternatively, at least 1 hour. In other
 embodiments, the conversion time ranges from 15 minutes to 12
 hours; alternatively, from 30 minutes to 6 hours; or alternatively, from
 45 minutes to 3 hours.
 DETD The conversion of the ***thiol*** group to a thioacrylate
 group can be performed at any conversion pressure that maintains the
 thiol ester and the acrylate compound in the liquid state. In some
 embodiments, the conversion pressure ranges from 0 psia to 2000

psia. In other embodiments, the conversion pressure ranges from 0 psia to 1000 psia; or alternatively, from 0 psia to 500 psia.

DETD Process for Producing Cross-Linked ***Thiol*** Ester

DETD As an embodiment of the present invention, a process for producing a cross-linked ***thiol*** ester composition is advantageously provided. Minimally, in some embodiments, the process to produce the cross-linked ***thiol*** ester composition comprises contacting a ***thiol*** ester composition with an oxidizing agent and reacting the ***thiol*** ester composition and an oxidizing agent to form the ***thiol*** ester oligomer having at least two ***thiol*** ester monomers connected by a polysulfide linkage having the structure --S.sub.Q-- , wherein Q is an integer greater than 1. The disclosed method may be applied to any ***thiol*** ester described herein to produce any cross-linked ***thiol*** ester composition as described herein. The process to produce the cross-linked ***thiol*** ester composition can also include any additional process steps or process conditions as described herein.

DETD When elemental sulfur is used as the oxidizing agent, the quantity of elemental sulfur utilized to form the cross-linked ***thiol*** ester composition is determined as a function of the ***thiol*** sulfur content of the ***thiol*** ester composition. In an aspect, the weight ratio of elemental sulfur to ***thiol*** sulfur in the ***thiol*** ester composition is at least 0.5. In some embodiments, the weight ratio of elemental sulfur to ***thiol*** sulfur in the ***thiol*** ester composition is at least 5; alternatively, at least 10, alternatively, at least 15, or alternatively, at least 20. In other embodiments, the weight ratio of elemental sulfur to ***thiol*** sulfur in the ***thiol*** ester composition ranges from 0.5 to 32; alternatively, ranges from 1 to 24; alternatively, ranges from 2 to 16; or alternatively, ranges from 3 to 10.

DETD In an aspect, the reaction of the ***thiol*** ester and elemental sulfur occurs in the presence of a catalyst. The catalyst can be any catalyst that catalyzes the formation of the polysulfide linkage between

at least two ***thiol*** ester monomers. In some embodiments, the catalyst is an amine. In further embodiments, the catalyst is a tertiary amine.

DETD The formation of the cross-linked ***thiol*** ester can occur in a batch reactor or a continuous reactor, as described herein. The formation of the cross-linked ***thiol*** ester can occur at any temperature capable of forming the ***thiol*** ester. In some embodiments, the formation of the cross-linked ***thiol*** ester can occur at a temperature greater than 25.degree. C. In other embodiments, the formation of the cross-linked ***thiol*** ester can occur at a temperature greater than 50.degree. C.; alternatively, greater than 70.degree. C.; or alternatively, greater than 80.degree. C. In yet other embodiments, the formation of the cross-linked ***thiol*** ester occurs at a temperature from 25.degree. C. to 150.degree. C.; alternatively, from 50.degree. C. to 150.degree. C.; alternatively, from 70.degree. C. to 120.degree. C.; or alternatively, from 80.degree. C. to 110.degree. C.

DETD The time required to form the cross-linked ***thiol*** ester can be any time required to form the desired cross-linked ***thiol*** ester. Generally, the time required to form the cross-linked ***thiol*** ester is at least 15 minutes. In some embodiments, the time required to form the cross-linked ***thiol*** ester is at least 30 minutes; alternatively, at least 1 hour; or alternatively, at least 2 hours. In yet other embodiments, the time required to form the cross-linked ***thiol*** ester ranges from 15 minutes to 72 hours; alternatively, from 30 minutes to 48 hours; alternatively, from 1 hour minutes to 36 hours; or alternatively, from 2 hours and 24 hours.

DETD In embodiments, the process to produce the cross-linked ***thiol*** ester further comprises a step to remove residual hydrogen sulfide. In some embodiments the cross-linked ***thiol*** ester is vacuum stripped. In some embodiments, the cross-linked ***thiol*** ester is vacuum striped at a temperature between 25.degree. C. and 250.degree. C.; alternatively, between 50.degree. C. and 200.degree. C.; or alternatively, 75 and 150.degree. C. In some embodiments, the cross-linked ***thiol*** ester oil is sparged with an inert gas to remove residual hydrogen sulfide. In other embodiments, the cross-linked

thiol ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; alternatively, between 50.degree. C. and 200.degree. C.; or alternatively, between 75 and 150.degree. C. In yet other embodiments, the vacuum stripping is performed while sparging the cross-linked ***thiol*** ester with an inert gas. In yet other embodiments, the vacuum stripping is performed while sparging the cross-linked ***thiol*** ester an inert gas at a temperature between 25.degree. C. and 250.degree. C.; alternatively, between 50.degree. C. and 200.degree. C.; or alternatively, 75 and 150.degree. C. In some embodiments, the inert gas is nitrogen.

DETD Generally, the stripped or sparged cross-linked ***thiol*** ester comprises less than 0.1 weight percent hydrogen sulfide. In other embodiments, the stripped or sparged ***thiol*** -containing ester oil comprises less than 0.05 weight percent hydrogen sulfide; alternatively, less than 0.025 weight percent hydrogen sulfide; or alternatively, less than 0.01 weight percent hydrogen sulfide.

DETD The present invention advantageously provides processes for producing sulfide-containing esters as embodiments of the present invention. Generally, the sulfide-containing esters can be prepared by two processes. As an embodiment of the present invention, the first process used to produce a sulfide-containing ester comprises contacting an unsaturated ester and a ***mercaptan*** and reacting the unsaturated ester and ***mercaptan*** to form a sulfide-containing ester.

As another embodiment of the present invention, the second process used to produce a sulfide-containing ester comprises contacting an epoxidized unsaturated ester and a ***mercaptan*** sulfide and reacting the unsaturated ester and ***mercaptan*** to form a sulfide-containing ester. Additional aspects of the two sulfide-containing ester production processes are described below.

DETD The sulfide-containing esters and sulfide-containing ester compositions described herein can be produced by a process comprising contacting a ***mercaptan*** and an unsaturated ester and reacting the ***mercaptan*** and the unsaturated ester to form a sulfide-containing ester. The process can be applied to any of the unsaturated esters and ***mercaptans*** described herein. The process for producing

the sulfide-containing ester can also include any additional process steps or process conditions described herein. Additionally, the process for producing the sulfide-containing ester can form any sulfide-containing ester described herein.

DETD In some aspects, the reaction between the ***mercaptan*** and the unsaturated ester occurs in the presence of a solvent. In other aspects the reaction between the ***mercaptan*** and the unsaturated ester occurs in the substantial absence of a solvent. When the reaction occurs in the presence of a solvent, the solvent is selected from an aliphatic hydrocarbon, an ether, an aromatic compound, an alcohol, or any combination thereof. Generally, the solvent, regardless of its chemical class, can comprise from 1 to 20 carbon atoms; alternatively, from 3 to 10 carbon atoms. When the solvent includes an aliphatic hydrocarbon, the aliphatic hydrocarbon is butane, isobutane, pentane, hexane, heptane, octane, or any mixture thereof. When the solvent includes an aromatic compound, the aromatic compound is benzene, toluene, xylene, ethylbenzene, or any mixture thereof. When the solvent includes an alcohol, the alcohol is methanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol, 2-methyl-2-propanol, or any mixture thereof. When the solvent includes an ether, the ether is diethyl ether, dipropyl ether, tetrahydrofuran, or any mixture thereof.

DETD When a solvent is used for the reaction between the ***mercaptan*** and the unsaturated ester, the quantity of solvent can be any amount that facilitates the reaction, as understood by those of skill in the art. In some embodiments, the mass of the solvent is less than 30 times the mass of the unsaturated ester. In other embodiments, the mass of the solvent is less than 20 times the mass of the unsaturated ester; alternatively, less than 15 times the mass of the unsaturated ester; alternatively, less than 10 times the mass of the unsaturated ester; or alternatively, less than 5 times the mass of the unsaturated ester. In other embodiments, the mass of the solvent is from 2 times to 20 times the mass of the unsaturated ester; alternatively, from 3 times to 15 times the mass of the unsaturated ester; alternatively, from 4

times to 15 times the mass of the unsaturated ester; or alternatively, from 5 times to 10 times the mass of the unsaturated ester.

DETD The molar ratio of ***mercaptan*** to molar equivalents of unsaturated ester carbon-carbon double bonds (herein after " ***mercaptan*** to carbon-carbon double bond molar ratio") utilized in the process to produce the sulfide-containing ester can be any ***mercaptan*** to carbon-carbon double bond molar ratio that produces the desired sulfide-containing ester. The molar equivalents of unsaturated ester carbon-carbon double bonds is calculated by the equation: $\frac{UES}{C_{dbd}} = \frac{UES_{GMW}}{C_{dbd,C}}$ In this equation, UES GMW is the average gram molecular weight of the unsaturated ester, UES Mass is the mass of the unsaturated ester, and UES C.dbd.C is the average number of double bonds per unsaturated ester molecule. In some embodiments, the ***mercaptan*** to carbon-carbon double bond molar ratio is greater than 0.25. In other embodiments, the ***mercaptan*** to carbon-carbon double bond molar ratio is greater than 0.5; alternatively, greater than 0.75; alternatively, greater than 1; alternatively, greater than 1.25; or alternatively, greater than 1.5.

1.5. In other embodiments, the ***mercaptan*** to carbon-carbon double bond molar ratio can range from 0.25 to 2; alternatively, from 0.5 to 1.5, or alternatively, from 0.75 to 1.25.

DETD In some aspects the reaction between the ***mercaptan*** and the unsaturated ester is catalyzed. The reaction of the ***mercaptan*** and the unsaturated ester can be catalyzed by a heterogeneous catalyst or homogeneous catalyst, as described herein. In some aspects, the reaction between the ***mercaptan*** and the unsaturated ester is initiated by a free radical initiator or ultraviolet radiation, as described herein.

DETD The free radical initiator can be any free radical initiator capable of forming free radicals under thermal or light photolysis. Generally, the free radical initiator is selected from the general class of compounds having a --N.dbd.N-- group or a --O-- O-- group. Specific classes of free radical initiators include diazo compounds, dialkyl peroxides, hydroperoxides, and peroxy esters. Specific initiators include azobenzene, 2,2'-azobis(2-methylpropionitrile, 4,4'-azobis(4-cyanovaleric acid), 1,1'-azobis(cyclohexanecarbonitrile), 2,2'-azobis(2methylpropane), 2,2'-azobis(2-methylpropionamidine)

dihydro-
chloride, methylpropionitrile, azodicarboxamide, tert-butyl
hydroperoxide, di-tert-butyl peroxide, octylperbenzoate. In some
embodiments, the free radical initiated reaction of the
mercaptan and the unsaturated ester is performed at a
reaction
temperature within $\pm .50$ degree. C. of the 1 hour half life of
the free
radical initiator. In other embodiments, the reaction temperature
is
within $\pm .25$ degree. C. of the 1 hour half life of the free
radical
initiator; alternatively, the reaction temperature is within
 $\pm .20$ degree. C. of the 1 hour half life of the free radical
initiator;
alternatively, the reaction temperature is within $\pm .15$ degree.
C. of
the 1 hour half life of the free radical initiator; or
alternatively,
the reaction temperature is within $\pm .10$ degree. C. of the 1
hour half
life of the free radical initiator. In embodiments where the free
radical initiated reaction of the ***mercaptan*** and the
unsaturated ester is initiated by light photolysis, the light can
be any
light capable creating free radicals. In some embodiments, the
light is
UV radiation. Other sources of light capable of creating free
radicals
will be apparent to those of skill in the art and are to be
considered
within the scope of the present invention.
DETD In another aspect, the reaction of the ***mercaptan*** and
the
unsaturated ester is initiated by UV radiation. In these
embodiments,
the UV radiation may be any UV radiation capable of initiating
the
reaction of the ***mercaptan*** and the unsaturated ester. In
some
embodiments, the UV radiation is generated by a medium pressure
mercury
lamp.
DETD The reaction of the ***mercaptan*** and the unsaturated
ester can
occur in a batch reactor of a continuous reactor. Any of the
batch or
continuous reactors described herein can be used in this
reaction. Other
suitable reactors will be apparent to those of skill in the art
and are
to be considered within the scope of the present invention.
DETD The reaction time for reacting the ***mercaptan*** and the
unsaturated ester can be any time required to form the
sulfide-containing ester. Generally, the reaction time is at
least 5
minutes. In some embodiments, the reaction time ranges from 5
minutes to
72 hours; alternatively, from 10 minutes to 48 hours; or
alternatively,

from 15 minutes to 36 hours.

DETD In some embodiments, the process to produce the sulfide-containing ester further comprises a step to remove any residual ***mercaptan*** that remains after reacting the ***mercaptan*** and the unsaturated ester. In some embodiments, the sulfide-containing ester is vacuum stripped to remove the residual ***mercaptan***. In some embodiments, the sulfide-containing ester is vacuum stripped at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the sulfide-containing ester is sparged with an inert gas to remove the residual ***mercaptan***. In some embodiments, the sulfide-containing ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In some aspects, the inert gas is nitrogen. Generally, the stripped or sparged sulfide-containing ester comprises less than 5 weight percent of the ***mercaptan***. In other embodiments, the stripped or sparged sulfide-containing ester comprises less than 2 weight percent of the ***mercaptan***; alternatively, less than 1 weight percent of the ***mercaptan***; or alternatively, less than 0.5 weight percent of the ***mercaptan***.

DETD The reaction between the ***mercaptan*** and the unsaturated ester can be performed at any temperature capable of forming the sulfide-containing ester. In some embodiments, the ***mercaptan*** and the unsaturated ester can be reacted at a reaction temperature of greater than -20.degree. C. In other embodiments, the reaction temperature is greater than 0.degree. C.; alternatively, greater than 20.degree. C.; alternatively, greater than 50.degree. C.; alternatively, greater than 80.degree. C.; or alternatively, greater than 100.degree. C. In yet other embodiments, the ***mercaptan*** and the unsaturated ester can be reacted at a temperature from -20.degree. C. to 250.degree. C.; alternatively, from 20.degree. C. to 200.degree. C.; or alternatively, from 80.degree. C. to 160.degree. C.

DETD The reaction between the ***mercaptan*** and the unsaturated ester can be performed at any pressure that maintains the ***mercaptan*** and the unsaturated ester in a substantially liquid state. In

some embodiments, the ***mercaptan*** and the unsaturated ester can be performed at a reaction pressure ranging from 0 psig to 2000 psig. In other embodiments, the reaction pressure ranges from 0 psig to 1000 psig; alternatively, from 0 psig to 500 psig; or alternatively, from 0 psig to 200 psig.

DETD Using the disclosed process, sulfide-containing ester having a low carbon-carbon double bond to sulfide group molar ratio can be produced. In an aspect, the process for producing the sulfide-containing ester forms a sulfide-containing ester having a carbon-carbon double bond to ***thiol*** group molar ratio of less than 1.5. Additional carbon-carbon double bond to sulfide group molar ratios are disclosed herein.

DETD As another embodiment of the present invention, another process for producing a class of sulfide-containing esters, which includes hydroxy sulfide-containing esters, is advantageously provided. In this embodiment, the hydroxy sulfide-containing esters and hydroxy sulfide-containing ester compositions can be produced by a process comprising the steps of contacting a ***mercaptan*** and an epoxidized unsaturated ester and reacting the ***mercaptan*** and the epoxidized unsaturated ester to produce or form the hydroxy sulfide-containing ester. The process can be applied to any ***mercaptan*** and/or any epoxidized unsaturated esters described herein. The process for producing the hydroxy sulfide-containing ester can also include any additional process steps or process conditions as described herein. Additionally, the process for producing the hydroxy sulfide-containing ester can form any hydroxy sulfide-containing ester as described herein.

DETD In some aspects, the reaction between the ***mercaptan*** and the unsaturated ester occurs in the presence of a solvent. In other aspects the reaction between the ***mercaptan*** and the unsaturated ester occurs in the substantial absence of a solvent. When the reaction occurs in the presence of a solvent, the solvent is selected from an aliphatic hydrocarbon, an ether, an aromatic compound, or any combination thereof.

Generally, the solvent, regardless of its chemical class, can comprise

from 1 to 20 carbon atoms; alternatively, from 3 to 10 carbon atoms.

When the solvent includes an aliphatic hydrocarbon, the aliphatic hydrocarbon is butane, isobutane, pentane, hexane, heptane, octane, or any mixture thereof. When the solvent includes an aromatic compound, the aromatic compound is benzene, toluene, xylene, ethylbenzene, or any mixture thereof. When the solvent includes an ether, the ether is diethyl ether, dipropyl ether, tetrahydrofuran, or any mixture thereof.

DETD When a solvent is used for the reaction between the ***mercaptan*** and the epoxidized unsaturated ester, the quantity of solvent can be any amount that facilitates the reaction, as understood by those of skill in the art. In some embodiments, the mass of the solvent is less than 30 times the mass of the epoxidized unsaturated ester. In other embodiments, the mass of the solvent is less than 20 times the mass of the epoxidized unsaturated ester; alternatively, less than 15 times the mass of the epoxidized unsaturated ester; alternatively, less than 10 times the mass of the epoxidized unsaturated ester; or alternatively, less than 5 times the mass of the epoxidized unsaturated ester. In other embodiments, the mass of the solvent is from 2 times to 20 times the mass of the epoxidized unsaturated ester; alternatively, from 3 times to 15 times the mass of the epoxidized unsaturated ester; alternatively, from 4 times to 15 times the mass of the epoxidized unsaturated ester; or alternatively, from 5 times to 10 times the mass of the epoxidized unsaturated ester.

DETD The reaction of the ***mercaptan*** and the epoxidized unsaturated ester can occur using any ***mercaptan*** to molar equivalents of ***epoxide*** groups in the epoxidized unsaturated ester (hereinafter referred to as " ***mercaptan*** to ***epoxide*** group molar ratio") that is capable of producing the herein described .alpha.-hydroxy ***thiol*** esters. The molar equivalents of epoxidized unsaturated ester epoxidized groups can be calculated by the equation: ##EQU4##

DETD In this equation, EUES GMW is the average gram molecular weight of the epoxidized unsaturated ester, EUES Mass is the mass of the epoxidized unsaturated ester, and EUES ***Epoxide*** is the average

number of *****epoxide***** groups per epoxidized unsaturated ester molecule. In some embodiments, the *****mercaptan***** to *****epoxide***** group molar ratio is greater than 0.2. In other embodiments, the *****mercaptan***** to *****epoxide***** group molar ratio is greater than 0.5; alternatively, greater than 1; or alternatively, greater than 2. In other embodiments, the hydrogen sulfide to *****epoxide***** group molar ratio ranges from 0.2 to 10; alternatively, from 0.5 to 8; alternatively, from 0.75 to 5; or alternatively, from 1 to 3.

DETD In some aspects, the reaction of the *****mercaptan***** and the epoxidized unsaturated ester occurs in the presence of a catalyst. Generally, the catalyst is any catalyst that is capable of catalyzing the reaction of the *****mercaptan***** and the epoxidized unsaturated ester to produce the desired hydroxy *****thiol***** ester. In one aspect, the catalyst is selected from the group consisting of homogeneous and heterogeneous catalysts. In other aspects, the catalyst is selected from the group consisting of zeolites, heterogeneous catalysts, homogeneous catalysts, and mixtures thereof. In another aspect, the catalyst is an amine. In other aspects, the catalyst is selected from the group consisting of cyclic conjugated amines, 1,8-diazabicyclo[5.4.0]undec-7-ene, 1,5-diazabicyclo[4.3.0]non-5-ene, and mixtures thereof.

DETD In some aspects, the reaction of the *****mercaptan***** and the epoxidized unsaturated ester occurs in the presence of a catalyst. Generally, the catalyst is any catalyst that is capable of catalyzing the reaction of the *****mercaptan***** and the epoxidized unsaturated ester to produce the desired hydroxy *****thiol***** ester. In some embodiments the catalyst is an organic base. In some embodiments, the catalyst can be 1,8-diazabicyclo[5.4.0]undec-7-ene. (What other catalysts may be used?)

DETD The reaction of the *****mercaptan***** and the epoxidized unsaturated ester can occur in a batch reactor or a continuous reactor. Any of the batch or continuous reactors described herein can be used in this reaction. Other suitable reactors will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD The time required for the reaction of the *****mercaptan***** and the epoxidized unsaturated ester can be any reaction time required to

form the described hydroxy sulfide-containing ester. Generally, the reaction time is at least 15 minutes. In some embodiments, the reaction time ranges from 15 minutes to 72 hours; alternatively, from 30 minutes to 48 hours; or alternatively, from 45 minutes to 36 hours.

DETD In some embodiments, the process to produce the hydroxy sulfide-containing ester further comprises a step to remove the residual ***mercaptan*** after reacting the ***mercaptan*** and the epoxidized unsaturated ester. In some embodiments the hydroxy sulfide-containing ester is vacuum stripped. In some embodiments, the hydroxy sulfide-containing ester is vacuum stripped at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In other embodiments, the hydroxy sulfide-containing ester is sparged with an inert gas to remove the ***mercaptan***. In some embodiments, the hydroxy sulfide-containing ester is sparged with an inert gas at a temperature between 25.degree. C. and 250.degree. C.; or alternatively, between 50.degree. C. and 200.degree. C. In some aspects, the inert gas is nitrogen.

Generally, the stripped or sparged hydroxy sulfide-containing ester comprises less than 5 weight percent of the ***mercaptan***. In other embodiments, the stripped or sparged hydroxy sulfide-containing ester comprises less than 2 weight percent of the ***mercaptan***; alternatively, less than 1 weight percent of the ***mercaptan***; or alternatively, less than 0.5 weight percent of the ***mercaptan***.

DETD The reaction between the ***mercaptan*** and the epoxidized unsaturated ester can be performed at any reaction temperature capable of forming the hydroxy sulfide-containing ester. In some embodiments, the reaction temperature is greater than -20.degree. C. In other embodiments, the reaction temperature is greater than 0.degree. C.; alternatively, greater than 20.degree. C.; alternatively, greater than 50.degree. C.; or alternatively, greater than 80.degree. C. In yet other embodiments, the reaction temperature ranges from -20.degree. C. to 200.degree. C.; alternatively, from 20.degree. C. to 170.degree. C.; or alternatively, from 80.degree. C. to 140.degree. C.

DETD The reaction between the ***mercaptan*** and the epoxidized unsaturated ester can be performed at any reaction pressure that maintains the ***mercaptan*** and the epoxidized unsaturated ester in a substantially liquid state. In some embodiments, the reaction pressure ranges from 0 psig to 2000 psig. In other embodiments, the reaction pressure ranges from 0 psig to 1000 psig; alternatively, from 0 psig to 500 psig; or alternatively, from 0 psig to 200 psig.

DETD In another aspect, the process to produce a hydroxy sulfide-containing ester produces a hydroxy sulfide-containing ester having an ***epoxide*** group to sulfide group molar ratio less than 2.

Other hydroxy sulfide-containing ester ***epoxide*** group to sulfide group molar ratios are described herein. (The next passage needs to be incorporated into the hydroxy ***thiol*** ester section along with the first sentence of this paragraph.) Alternatively, the hydroxy sulfide-containing ester ***epoxide*** group to ***thiol*** group molar ratio can be less than 1.5; alternatively, less than 1.0; alternatively, less than 0.5, alternatively, less than 0.25; or alternatively, less than 0.1. In other embodiments, the hydroxy sulfide-containing ester can be substantially free of ***epoxide*** groups.

DETD As an embodiment of the present invention, processes for producing a sulfonic acid-containing ester and for producing a sulfonate-containing ester are advantageously provided. Generally, the process for producing the sulfonic acid-containing ester comprises the steps of contacting a ***thiol*** ester and an oxidizing agent and oxidizing at least one ***thiol*** group of the ***thiol*** ester to produce a sulfonic acid group. The process for producing the sulfonate-containing ester comprises the steps of contacting a sulfonic acid-containing ester with a base and forming a sulfonate-containing ester.

DETD In an embodiment, the process to prepare a sulfonic acid-containing ester comprises the steps of contacting the ***thiol*** ester and the oxidizing agent and oxidizing the ***thiol*** ester to produce the sulfonic acid-containing ester. Generally the oxidizing agent oxidizes at least one ***thiol*** group of the ***thiol*** ester to a sulfonate group. The process to produce the sulfonic acid-containing ester composition can be applied to any ***thiol***

ester described herein to prepare any sulfonic acid-containing ester described herein. In some embodiments, the ***thiol*** ester includes a hydroxy group. For example, the ***thiol*** ester can be any hydroxy ***thiol*** ester described herein. The oxidizing agent can be any oxidizing agent described herein.

DETD In some aspects, the oxidation of the ***thiol*** ester occurs in the presence of a solvent. In some aspects, the solvent is water.

DETD The oxidizing agent that is contacted with the ***thiol*** ester can be any oxidizing agent capable of oxidizing a ***thiol*** group to a sulfonic acid group. In some embodiments, the oxidizing agent is oxygen. In other embodiments, the oxidizing agent is chlorine. In other embodiments, the oxidizing agent is dimethyl sulfoxide. In yet other embodiments, the oxidizing agent is a combination of a hydrogen halide and a catalytic amount of a dialkyl sulfide, such as dimethyl sulfoxide.

skill in Other suitable oxidizing agents will be apparent to those of the art and are to be considered within the scope of the present invention.

DETD The oxidation of the ***thiol*** ester can be performed at any temperature capable of converting the ***thiol*** ester to a sulfonic acid-containing ester. In some embodiments, the ***thiol*** ester is oxidized at a temperature greater than -20.degree. C. In other embodiments, the ***thiol*** ester is oxidized at a temperature greater than 0.degree. C.; alternatively, greater than 20.degree. C.; or alternatively, greater than 50.degree. C.

DETD The time required for the oxidation of the ***thiol*** ester can be any time required to form the desired sulfonic acid-containing ester. Generally, the time required for the oxidation of the ***thiol*** ester is at least 15 minutes; alternatively, at least 30 minutes; alternatively, at least 45 minutes; or alternatively, at least 1 hour.

alternatively, In some embodiments, the time required for the oxidation of the ***thiol*** ester ranges from 15 minutes to 12 hours; alternatively, from 30 minutes to 6 hours; alternatively, from 45 minutes to 3 hours.

DETD The oxidation of the ***thiol*** ester can be performed at any pressure that maintains the ***thiol*** ester and the oxidation agent in the proper state, which is not always a liquid state, to

oxidize the ***thiol*** ester to a sulfonic acid-containing ester. For example, when the oxidation agent is chlorine, the chlorine can be in the gaseous state. In some embodiments, the oxidation of the ***thiol*** ester can be performed at a pressure ranging from 0 to 2000 psig. In other embodiments, the oxidation of the ***thiol*** ester can be performed at a pressure ranging from 0 to 1000 psig; or alternatively, 0 to 500 psig.

DETD The oxidation of the ***thiol*** ester can be performed in a batch reactor or a continuous reactor, as described herein. Additionally, the process to produce the sulfonic acid-containing ester can comprise additional process steps as recognized by those skilled in the art.

DETD The formation of the sulfonate-containing ester can be performed at any temperature capable of converting the sulfonic acid group of the sulfonic acid-containing ester to a sulfonate group. In some embodiments, the sulfonate-containing ester is formed at a temperature greater than -20.degree. C. In other embodiments, the ***thiol*** ester is oxidized at a temperature greater than 0.degree. C.; alternatively, greater than 20.degree. C.; or alternatively, greater than 50.degree. C. In yet other embodiments, the ***thiol*** ester is oxidized at a temperature ranging from 0.degree. C. to 250.degree. C.; alternatively, from 0.degree. C. to 150.degree. C.; or alternatively, from 20.degree. C. to 100.degree. C.

DETD A preferred sulfur-containing vegetable oil is MVO available from Chevron Phillips Chemical Co. under the tradename Polymercaptan 358. Polymercaptan 358 is made by the free radical addition of hydrogen sulfide to the double bonds in soybean oil. Typically, Polymercaptan 358 has a ***thiol*** sulfur content of 5 to 10% and equivalent weights of 640 to 320, respectively.

DETD Another preferred sulfur-containing vegetable oil useful as part of the isocyanate-reactive component is a MHVO such as mercapto-hydroxy soybean oil. As described herein, a preferred mercapto-hydroxy soybean oil is made by the free radical addition of hydrogen sulfide to epoxidized soybean oil. Typically, the mercapto and hydroxy functionalities are equal and the ***mercaptan*** content is about 8.3%.

thiol sulfur. The equivalent weight of this material is 192, which

includes both mercapto and hydroxy functionalities.

DETD Yet another preferred sulfur-containing vegetable oil useful as part of the isocyanate-reactive component is a CMVO such as sulfur cross-linked mercaptanized soybean oil. Sulfur cross-linked mercaptanized soybean oil is made by the addition of elemental sulfur to mercaptanized soybean oil. In this process, a portion of the ***mercaptan*** groups are consumed as cross-linking sites for the sulfur. Typical sulfur cross-linked mercaptanized soybean oil products by Chevron Phillips Chemical Co. include Runs #22, 194, 195, 196 and 197 and have a ***thiol*** sulfur content ranging from about 8.0% to 1.4% and equivalent weights ranging from about 400 to about 2250, respectively.

DETD For epoxy polymer encapsulated CRF material made from sulfur-containing vegetable oil, it has been found that the use of a tertiary amine catalyst is highly preferred. The amount used is such to be sufficient to give the desired reaction rate for the production of the encapsulated slow release fertilizer product. A non-limiting example of a suitable amine catalyst is diazobicycloundecacene also known as 1,8-diazabicyclo[5,4,0]undec-7-ene [CAS# ***6674-22-2***] or "DBU", which is preferably used in the range of about 0.1% to 0.5% by weight of the coating. Other suitable catalyst materials will be apparent to those of ordinary skill in the art.

DETD The preferred sulfur-containing vegetable oil to be used in production of an epoxy polymer coated CRF material is MHVO such as mercapto-hydroxy soybean oil. One such material is mercapto-hydroxy soybean oil known as MHSO 566-84 produced by Chevron Phillips Chemical Co. This preferred material contains 8.33% ***thiol*** sulfur, with an equivalent weight of 384, based upon the ***mercaptan*** functionality.

DETD The unsaturated ester used as a feedstock to produce the ***thiol*** ester compositions described herein can be described using a number of different methods. One method of describing the unsaturated ester feedstock is by the number of ester groups and the number of carbon-carbon double bonds that comprise each unsaturated ester oil molecule. Suitable unsaturated ester used as a feedstock to produce the ***thiol*** ester compositions described herein minimally comprise at

least 1 ester group and at least 1 carbon-carbon double bond.
However, beyond this requirement, the number of ester groups and carbon-carbon double bonds comprising the unsaturated esters are independent elements and can be varied independently of each other. Thus, the unsaturated esters can have any combination of the number of ester groups and the number of carbon-carbon double bonds described separately herein. Suitable, unsaturated esters can also contain additional functional groups such as alcohol, aldehyde, ketone, epoxy, ether, aromatic groups, and combinations thereof. As an example, the unsaturated esters can also comprise hydroxy groups. An example of an unsaturated ester that contains hydroxy groups is castor oil. Other suitable unsaturated esters will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD In yet another aspect, the polyol or mixture of polyols used to produce the unsaturated ***thiol*** ester has a molecular weight or average molecular weight less than 500. In other embodiments, the polyol or mixture of polyols have a molecular weight or average molecular weight less than 300; alternatively less than 200; alternatively, less than 150; or alternatively, less than 100.

DETD Specific carboxylic acids used as a component of the carboxylic acid composition used to produce the unsaturated ester oil can have from 3 to 30 carbon atoms per carboxylic acid molecule. In some embodiments the carboxylic acid is linear. In some embodiments the carboxylic acid is branched. In some embodiments the carboxylic acid is a mixture of linear and branched carboxylic acids. In some embodiments the carboxylic acid can also comprise additional functional groups including alcohols, aldehydes, ketones, and ***epoxides***, among others.

DETD Minimally, the epoxidized unsaturated ester comprises at least one ***epoxide*** group. In an embodiment the epoxidized unsaturated ester comprises at least 2 ***epoxide*** groups; alternatively, at least 3 ***epoxide*** groups; or alternatively, at least 4 ***epoxide*** groups.

from 2 In other embodiments, the epoxidized unsaturated ester comprises from 2 to 9 ***epoxide*** groups; alternatively, from 2 to 4

epoxide groups; alternatively, from 3 to 8
 epoxide groups; or alternatively, from 4 to 8 ***epoxide*** groups.
 DETD In some embodiments, the unsaturated ester comprises a mixture
 of epoxidized unsaturated esters. In this aspect, the number of
 epoxide groups in the epoxidized unsaturated ester is
 best described as an average number of ***epoxide*** groups per
 epoxidized unsaturated ester molecule. In some embodiments, the
 epoxidized unsaturated esters have an average of at least 1.5
 epoxide groups per epoxidized unsaturated ester
 molecule;
 alternatively, an average of at least 2 ***epoxide*** groups
 per epoxidized unsaturated ester molecule; alternatively, an average
 of at least 2.5 ***epoxide*** groups per epoxidized unsaturated
 ester molecule; or alternatively, an average of at least 3
 epoxide groups per epoxidized unsaturated ester molecule. In other
 embodiments,
 the epoxidized unsaturated esters have average of from 1.5 to 9
 epoxide groups per epoxidized unsaturated ester
 molecule;
 alternatively, an average of from 3 to 8 ***epoxide*** groups
 per epoxidized unsaturated ester molecule; alternatively, an average
 of from 2 to 4 ***epoxide*** groups per epoxidized unsaturated ester
 molecule; or alternatively, from of 4 to 8 ***epoxide***
 group per epoxidized unsaturated ester molecule.
 DETD The ***thiol*** composition can include an average of
 greater than 0 to about 4 ***epoxide*** groups per triglyceride. The
 thiol composition can also include an average of
 greater than 1.5 to about 9 ***epoxide*** groups per triglyceride.
 DETD ***Mercaptans***
 DETD Within some embodiments, an unsaturated ester or an epoxidized
 unsaturated ester is contacted with ***mercaptan***. Within
 these embodiments, the ***mercaptan*** can be any ***mercaptan***
 comprising from 1 to 20 carbon atoms. Generally, the
 mercaptan can have the following structure: HS--R.sup.3 wherein R3 is
 a C1 to C20 organyl groups or a C1 to C20 hydrocarbyl groups. In further
 embodiments the R3 can be a C2 to C10 organyl group or a C2 to
 C10 hydrocarbyl group. In some embodiments, the ***mercaptan***
 composition comprises a solvent. In one aspect, the
 mercaptan composition comprises at least one other functional group.
 DETD The at least one other functional group can be selected from
 several different groups. For example, the at least one other functional
 group

is an alcohol group, a carboxylic alcohol group, a carboxylic ester group, an amine group, a sulfide group, a ***thiol*** group, a methyl or ethyl ester of a carboxylic acid group, or combinations thereof. Other types of functional groups will be apparent to those of skill in the art and are to be considered within the scope of the present invention.

DETD In some embodiments, the ***mercaptan*** is selected from the group consisting of 3-mercaptopropyl-trimethoxysilane, 2-mercaptopyridine, 4-mercaptopyridine, 2-mercaptopyrimidine, mercaptopyruvic acid, mercaptosuccinic acid, 2-mercaptonicotinic acid, 6-mercaptonicotinic acid, 2-mercaptophenol, 4-mercaptophenol, 3-mercapto-1,2-propanediol, 3-mercapto-1,2-propanediol, 3-mercapto-1-propanesulfonic acid, 1-mercapto-2-propanol, 3-mercapto-1-propanol, 2-mercaptopropionic acid, 3-mercaptopropionic acid, 2-mercaptobenzyl alcohol, 3-mercapto-2-butanol, 4-mercapto-1-butanol, 2-mercaptoethanesulfonic acid, 2-mercaptoethanol, 2-mercaptoethyl ether, 2-mercaptoethyl sulfide, 16-mercaptohexadecanoic acid, 6-mercapto-1-hexanol, 4'-mercaptoacetanilide, mercaptoacetic acid, 2-mercaptobenzoic acid, 3-mercaptobenzoic acid, 4-mercaptobenzoic acid, 2-mercaptothiazoline, 3-mercapto-1H-1,2,4-triazole, 11-mercaptoundecanoic acid, 1-mercapto-1-undecanol, or combinations thereof.

DETD In some embodiments, the ***mercaptan*** is selected from the group consisting of beta-mercaptoethanol, 2-mercaptophenol, 3-mercaptophenol, 4-mercaptophenol, 1-mercapto-2-propanol, 1-mercapto-3-propanol, mercaptoacetic acid, 2-mercaptopropionic acid, 3-mercaptopropionic acid, 2-mercaptobenzoic acid, 3-mercaptobenzoic acid, 4-mercaptobenzoic acid, 2-mercaptobenzylalcohol, 3-mercapto-2-butanol, 4-mercapto-1-butanol, 2-mercaptoethyl ether, 2-mercaptoethyl sulfide, 6-mercapto-hexanol, 3-mercapto-1,2-propanediol, mercaptosuccinic acid, and mixtures thereof.

In further embodiments, the ***mercaptan*** is selected from the group consisting of beta-mercaptoethanol, 1-mercapto-2-propanol, 1-mercapto-3-propanol, 2-mercaptobenzylalcohol, 3-mercapto-2-butanol, 4-mercapto-1-butanol, 6-mercapto-hexanol, 3-mercapto-1,2-propanediol, and mixtures thereof. In further embodiments, the ***mercaptan*** is selected from the group consisting of 2-mercaptophenol, 3-mercaptophenol, 4-mercaptophenol, and mixtures thereof. In yet further

embodiments, the
mercaptan is selected from the group consisting
mercaptoacetic
acid, 2-mercaptopropionic acid, 3-mercaptopropionic acid,
2-mercaptobenzoic acid, 3-mercaptobenzoic acid, 4-mercaptobenzoic
acid,
mercaptosuccinic acid, and mixtures thereof.
DETD Within some embodiments, the inventive compositions described
herein
are reacted with an isocyanate compound to produce a
polythiourethane
composition. The isocyanate may be any isocyanates capable of
reacting
with the ***thiol*** esters, hydroxy ***thiol*** esters,
and a
cross-linked ***thiol*** esters described herein to form a
polyurethane composition. Generally, the isocyanate compound has
at
least two isocyanate groups.
DETD In order to quantitatively measure the ***thiol*** sulfur,
the
thiol sulfur analyses were conducted using silver
nitrate
titration in accordance with ASTM D3227, with the following
modifications designed to minimize probe fouling by silver salts:
the
samples were diluted in a known mass of tetrahydrofuran. The
silver
nitrate concentration was 0.01 N standardized against potassium
iodide.
DETD ***Thiol*** sulfur was analyzed by three different tests.
The first
test used was the modified ASTM D3227, which resulted in a
thiol
sulfur measurement of 4.64%. The second test used to measure the
thiol sulfur was SLP-1204, which is a test developed by
Chevron
Phillips Chemical Company LLP. By using the SLP-1204 test, the
resulting
thiol sulfur measurement was 4.28%. Lastly, the total
sulfur was
measured by combustion analysis, which resulted in a total sulfur
measurement of 4.27%.
DETD Vegetable oil (42 kg) was charged to a 100-gallon holding
vessel. The
vessel was purged with nitrogen and returned to atmospheric
pressure.
Hydrogen sulfide (174 kg) was charged to the holding vessel. The
vessel
temperature was controlled from 25-30.degree. C. while the
pressure was
typically maintained between 380-400 psig. The reactants were
continuously rolled from the holding tank through a stainless
steel
tubular photochemical reactor containing a 7.5 KW Hanovia medium
pressure mercury lamp contained within a quartz tube. Reactor
temperature, pressure, and composition were monitored over the
course of
the reaction. The reaction time was dependent upon reaching a
desired

composition of ***thiol*** sulfur. Upon completion, the unreacted hydrogen sulfide was slowly vented from the system. Residual H.sub.2S was removed at 100.degree. C. and reduced pressure while passing nitrogen through a nitrogen sparge tube. The product was drained from the bottom of the reactor into a clean drum. The ***thiol*** sulfur measurements were 11.0% when using the modified ASTM D3227, 8.74% when using SLP-1204, and the total sulfur was 11.21% when using combustion analysis (total sulfur). DETD The resulting mercaptanized soybean oil was subjected to nitrogen sparging under reduced pressure at 100.degree. C. for a period of 4 hours to remove any residual hydrogen sulfide. The ***thiol*** sulfur measurements were 13.0% when using the modified ASTM D3227, 9.82% when using SLP-1204, and 11.69% when using combustion analysis. DETD Table 1 provides the properties of the mercaptanized soybean oil produced in examples 1-3.

TABLE 1

Mercaptanized Soybean Oil Product Properties

C.dbd.C	Cyclic Sulfide to ***Thiol*** Sulfur.sup..dagger. Group		
	to ***Thiol*** (wt %)	groups Molar Ratio	Molar Ratio
Example			
1	4.28	0.02	2.79
2	11.0	0.03	0.26
3	13.0	0.03	0.51

.sup..dagger. ***Thiol*** sulfur content determined by the modified ASTM D3227

DETD Soybean oil was charged to a 1000 gallon stirred reactor. Hydrogen sulfide was then charged to the reactor. After the hydrogen sulfide was charged to the reactor, the stirrers and the UV lamps were turned on and the reaction allowed to build temperature and pressure as the reaction proceed. The reaction was continued until a minimum ***thiol*** sulfur content of 8 weight percent was achieved. After reaction was completion, the excess hydrogen sulfide was flashed from the reactor. For runs 2-5, the mercaptanized soybean oil product underwent an additional hydrogen sulfide stripping step comprising stripping hydrogen sulfide from the product under vacuum, 50 mm Hg, at 250.degree. F. (only true for runs 2-5).

DETD Table 3 provides the details of the analysis of the mercaptanized soybean oil producing in the five 1000 gallon reactor runs.

TABLE 3

1000 gallon reactor Mercaptanized Soybean Oil Product Properties				
		Cyclic Sulfide to		Side Chain
		Thiol	***Thiol***	C.dbd.C
Run	Containing Sulfur.sup..dagger. Groups	groups		
Number	(wt %)	Molar Ratio	Molar Ratio	(%)
1	9.3	--	--	71.6
2	9.6	0.04	0.48	72.3
3	9.2	0.03	0.59	69.1
4	9.3	0.03	0.62	71.6
5	10.1	0.03	0.54	72.3

.sup..dagger. ***Thiol*** sulfur content determined by Raman spectroscopy

Mercaptanized Castor Bean Oil

DETD The analytical properties of the two mercaptanized castor oil products are provide in Table 4.

TABLE 4

Mercaptanized Castor Oil Product Properties				
		C.dbd.C to		Side Chain
		Thiol	***Thiol***	groups
Containing	Sulfur.sup..dagger. Groups			
Example	(wt %)	Molar Ratio	(%)	
1	6.4	0.52	64.1	
2	7.4	0.26	77.7	

.sup..dagger. ***Thiol*** sulfur content determined by Raman spectroscopy

Mercaptohydroxy Soybean Oil Synthetic Procedure

DETD Epoxidized Soybean Oil (700 g, .about.0.7 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 4.7 g, 30.5 mmol) were charged to a 1-L Hastelloy C autoclave reactor that was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 132.0 g, 3.87 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 8 hrs, during which time the reactor pressure decreased from a maximum of 351 psig to 219 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space

was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<5 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content of 7.53 wt. %, 2.5 SH/molecule, or 2.35 meq SH/g. Combustion analysis indicated C, 64.37%, H, 10.20%, N, <0.15%, and S, 9.51%. DETD Epoxidized Soybean Oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor, and the vessel was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 97.degree. C. with stirring for 14 hrs, during which time the reactor pressure decreased from a maximum of 509 psig to 229 psig. The stirrer was stopped and while still warm (90-95.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content of 4.14 wt. %, 1.4 SH/molecule, or 1.29 meq SH/g. Combustion analysis indicated C, 65.18%, H, 10.17%, N, <0.15%, and S, 7.80%. DETD Epoxidized Soybean Oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor, and the vessel was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 10 hrs, during which time the reactor pressure decreased from a maximum of 578 psig to 489 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space

was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ****thiol**** sulfur (titration with modified ASTM D3227) content of 8.28 wt. %, 2.8 SH/molecule, or 2.58 meq SH/g. Combustion analysis indicated C, 65.24%, H, 9.52%, N, 0.18%, and S, 9.53%. DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor that was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 12 hrs, during which time the reactor pressure decreased from a maximum of 587 psig to 498 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ****thiol**** sulfur (titration by modified ASTM D3227) content of 8.24 wt. %, 2.8 SH/molecule, or 2.57 meq SH/g. Combustion analysis indicated C, 63.39%, H, 10.01%, N, <0.15%, and S, 8.76%. DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor, and the vessel was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 8 hrs, during which time the reactor pressure decreased from a maximum of 606 psig to 537 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm

(80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content of 7.34 wt. %, 2.5 SH/molecule, or 2.29 meq SH/g. Combustion analysis indicated C, 64.47%, H, 10.18%, N, <0.15%, and S, 8.40%. DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor that was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 6 hrs, during which time the reactor pressure decreased from a maximum of 586 psig to 556 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual H.sub.2S. The resulting light yellow, viscous sticky oil had a ***thiol*** sulfur (titration by modified ASTM D3227) content of 5.93 wt. %, 2.0 SH/molecule, or 1.85 meq SH/g. Combustion analysis indicated C, 65.26%, H, 10.19%, N, <0.15%, and S, 8.43%. DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged to a 1-L Hastelloy C autoclave reactor, and the vessel was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured into the stirred reactor contents through a dip tube in the liquid space. The reaction mixture was heated and maintained at 85.degree. C. with stirring for 4 hrs, during which time the reactor pressure decreased from a maximum of 595 psig to 554 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was slowly vented to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under

vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual

H.sub.2S. The resulting light yellow, viscous sticky oil had a ****thiol*** sulfur (titration by modified ASTM D3227) content of 5.36 wt. %, 1.8 SH/molecule, or 1.67 meq SH/g. Combustion analysis indicated

C, 65.67%, H, 10.17%, N, 0.34%, and S, 9.84%.

DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged

to a 1-L Hastelloy C autoclave reactor that was pressure tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was then pressured

into the stirred reactor contents through a dip tube in the liquid

space. The reaction mixture was heated and maintained at 85.degree. C.

with stirring for 4 hrs, during which time the reactor pressure decreased from a maximum of 577 psig to 519 psig. The stirrer was stopped and while still warm (80-85.degree. C.), excess H.sub.2S

was

slowly vented to a low-pressure flare. The reactor vapor space was then

swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under

vacuum (<50 mmHg) at 130-140.degree. C. for 16 hrs to remove residual

H.sub.2S. The resulting light yellow, viscous sticky oil had a ****thiol*** sulfur (titration with AgNO.sub.3) content of 5.85 wt. %, 2.0 SH/molecule, or 1.82 meq SH/g. Combustion analysis indicated

C, 65.09%, H, 10.15%, N, 0.35%, and S, 10.63%.

DETD Epoxidized soybean oil (600 g, .about.0.6 mol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 5.0 g, 32.4 mmol) were charged

to a 1-L Hastelloy C autoclave reactor, and the vessel was pressure

tested to 630 psig. Hydrogen sulfide (H.sub.2S, 204.0 g, 5.99 mol) was

then pressured into the stirred reactor contents through a dip tube in

the liquid space. The reaction mixture was heated and maintained at

85.degree. C. with stirring for 2 hrs, during which time the reactor

pressure decreased from a maximum of 577 psig to 508 psig. The stirrer

was stopped and while still warm (80-85.degree. C.), excess H.sub.2S was

slowly vented to a low-pressure flare. The reactor vapor space was then

swept with N.sub.2 for 1 hr and the reactor contents drained warm (80-85.degree. C.). The reaction product was N.sub.2 sparged under

vacuum (<5 mmHg) at 130-140.degree. C. for 16 hrs to remove residual

H.sub.2S. The resulting light yellow, viscous sticky oil had a
 thiol sulfur (titration by modified ASTM D3227) content
 of 5.07 wt. %, 1.7 SH/molecule, or 1.58 meq SH/g. Combustion analysis
 indicated
 C, 63.96%, H, 10.01%, N, 0.35%, and S, 11.22%.
 DETD Table 5 provides the properties of the mercaptohydroxy soybean
 oil
 samples produced in Examples 1-10.
 TABLE 5

per	***Epoxides***		***Mercaptan***		
	Reaction	Reaction	Sulfur	SH per	groups left
Example	Time (hrs)	Temp (.degree. C.)	(wt. %)	.sup.1 molecule	.sup.2
	molecule.sup.3	Molar Ratio			
1	0	N/A	N/A	0	4.3
--					
2	8	85	7.53	2.5	1.8
	0.72				
3	14	97	4.14	1.4	2.9
	2.07				
4	10	85	8.28	2.8	1.5
	0.54				
5	12	85	8.24	2.8	1.5
	0.54				
6	8	85	7.34	2.5	1.8
	0.72				
7	6	85	5.93	2.0	2.3
	1.15				
8	4	85	5.36	1.8	2.5
	1.40				
9	4	85	5.85	2.0	2.3
	1.15				
10	2	85	5.07	1.7	2.6
	1.529				

.sup.1Thiol sulfur was determined by silver nitrate oxidation using ASTM
 D 3227
 .sup.2Determined by wt. % ***thiol*** sulfur
 .sup.3Determined by subtracting the SH/molecule from the starting
 material
 epoxide content
 DETD Epoxidized soybean oil and the catalyst were charged to a 1-L
 Hastelloy
 C autoclave reactor, and the vessel was pressure tested to 1000
 psig.
 Hydrogen sulfide was then pressured into the stirred reactor
 contents
 through a dip tube in the liquid space. The reaction mixture was
 heated
 and maintained at temperature a set period of time with stirring
 for 12
 hrs. During the reaction time the reactor pressure usually
 decreased. At

the end of the reaction time, the stirrer was stopped and excess H.sub.2S was slowly vented while the reaction mixture was warm to a low-pressure flare. The reactor vapor space was then swept with N.sub.2 for 1 hr and the reactor contents drained. The reaction product was N.sub.2 sparged under vacuum (<50 mmHg) at 100.degree. C. for 16 hrs to remove residual H.sub.2S. Table 6 provides the reaction conditions used to produce the mercaptohydroxy soybean oils for several runs and the ***thiol*** sulfur content of the mercaptohydroxy soybean oils produced.

TABLE 6

Mercaptohydroxy Soybean Oil Production Runs

Epoxidized Soybean Oil Production Data						
Run	Temperature	Time	Catalyst	H.sub.2S	H.sub.2S: Sulfur	***Epoxide***
(minutes)	(g)	(g)	(g)	***Thiol***	sup.a Molar Ratio	(.degree. C.)
	(wt. %)					
556-41.sup..dagger.	249.6		1.950	214.0	5.86	64
728	5.69					
556-53.sup..dagger.	250.0		2.000	213.0	5.81	100
370	9.04					
556-47.sup..dagger.	250.5		1.050	213.0	5.81	101
720	10.47					
407-81D.sup..dagger.	500.0		4.200	255.0	3.49	85
480	7.53					
407-86.sup..dagger.	600.0		5.000	204.0	2.07	85
600	8.28					
556-79.sup..dagger-dbl.	250.0		2.600	214.0	5.83	100
720	6.68					
556-80.sup..dagger-dbl.	251.0		5.000	214.0	5.81	100
720	9.51					

.sup..dagger.Catalyst was DBU

.sup..dagger-dbl.catalyst was triethylamine (TEA)

.sup.aThiol sulfur measured by silver nitrate titration using modified ASTM D

3227

DETD Run number 407-86 was subjected to the sodium methoxide methanolysis

procedure and subsequently analyzed by GC/MS. The GS/MS analysis indicated that the product had ***epoxide*** group to

thiol

group molar ratio of approximately 0.14. The methanolysis data also

indicated that an average of 80.4 percent of the product mercaptohydroxy

soybean oil contained sulfur.

DETD Mercaptanized soybean oil (900.1 g; 10.92 wt. % ***thiol*** sulfur,) was charged to a three necked flask along with elemental sulfur

pellets (9.6 g). The reaction mixture was heated to 120.degree. C. until sulfur dissolved and then cooled to 99.degree. C. Tributylamine (4.8 g) was charged to the reaction mixture with an addition funnel drop wise. The reaction mixture was mixed at 90.degree. C. for 2 hrs. H.sub.2S evolution was observed. The reaction product (904.8 g) was sparged with N.sub.2 under vacuum at 110.degree. C. for 4 hrs to remove residual H.sub.2S. The final product was a light yellow oil with a ***thiol*** sulfur of 6.33 wt. % (by modified ASTM D3227). The elemental combustion analysis was 70.19% C, 10.37% H; and 11.21% S.

DETD Mercaptanized soybean oil (900.0 g; 10.92 wt. % ***thiol*** sulfur,) was charged to a three necked flask along with elemental sulfur pellets (36.0 g). The reaction mixture was heated to 120.degree. C. until sulfur dissolved and then cooled to 100.degree. C. Tributylamine (4.8 g) was charged to the reaction mixture with an addition funnel drop wise. The reaction mixture was mixed at 90.degree. C. for 36 hrs. H.sub.2S evolution was observed. The reaction product (825.6 g) was sparged with N.sub.2 under vacuum at 90.degree. C. for 36 hrs to remove residual H.sub.2S. The reaction product was then sparged with N.sub.2 under vacuum at 110.degree. C. for 3 hrs to remove residual H.sub.2S. The final product was a light yellow oil with a ***thiol*** sulfur of 2.36 wt. % (by modified ASTM D3227). The elemental combustion analysis was 68.90% C; 11.07% H; and 12.25% S.

DETD Mercaptanized soybean oil (900.1 g; 10.92 wt. % ***thiol*** sulfur,) was charged to a three necked flask along with elemental sulfur pellets (18.0 g). The reaction mixture was heated to 125.degree. C. until sulfur dissolved and then cooled to 101.degree. C. Tributylamine (4.8 g) was charged to the reaction mixture with an addition funnel drop wise. The reaction mixture was mixed at 90.degree. C. for 2 hrs. H.sub.2S evolution was observed. The reaction product (901.5 g) was sparged with N.sub.2 under vacuum at 110.degree. C. for 4 hrs to remove residual H.sub.2S. The final product was a light yellow oil with a ***thiol*** sulfur of 4.9 wt. % (by modified ASTM D3227). The elemental combustion analysis was 69.58% C, 11.25% H; and 11.31% S.

DETD Mercaptanized soybean oil (900.2 g; 10.92 wt. % ***thiol*** sulfur,) was charged to a three necked flask along with elemental

sulfur pellets (45.0 g). The reaction mixture was heated to 125.degree. C. until sulfur dissolved and then cooled to 100.degree. C. Tributylamine (4.8 g) was charged to the reaction mixture with an addition funnel drop wise. The reaction mixture was mixed at 90.degree. C. for 2 hrs. H.sub.2S evolution was observed. The reaction product (915.0 g) was sparged with N.sub.2 under vacuum at 110.degree. C. for 4 hrs to remove residual H.sub.2S. The final product was a light yellow oil with a
 thiol sulfur of 1.41 wt. % (by modified ASTM D3227). The elemental combustion analysis was 68.35% C, 10.98% H; and 13.28% S. Numerous polythiourethane compositions were prepared by reacting a
 thiol ester composition with a diisocyanate in the presence of a catalyst by using the processes described herein for preparing such polythiourethane compositions. The compositions were produced using the different variables of feedstocks, diisocyanates, stoichiometry, and catalysts shown in Table 8. Once every combination of variable was used, over 1200 compositions were produced. Each of the feedstocks were reacted with each of the diisocyanates at each of the stoichiometries with each of the catalysts listed to produce the 1200+ compositions. The stoichiometry was based upon a
 thiol ester composition (MSO, MHSO, CMSO, MCO) active hydrogen (
 thiol and hydroxyl group) to diisocyanate equivalent ratio. For example, castor oil was reacted with toluene diisocyanate at a stoichiometric value of 1.25 while using Jeffol.RTM. A-480 as the catalyst. As another example, a
 thiol ester composition was reacted with methane diisocyanate at a stoichiometric value of 0.9 while using the DABCO catalyst. DETD In the first MCO polythiourethane example, MCO was weighed into a
 polyethylene beaker. To the MCO agent was added Luprinate at a
 thiol to isocyanate mole ratio of 0.95. To this reaction mixture was added dibutyl tin dilaurate (DBTDL) at a weight percent of 0.125 based upon the total weight of the ingredients. The three-component reaction mixture was then manually stirred with a wooden Popsicle stick. The entire pre-polymer mixture was then poured into a mold for curing

and cured using curing profile B. After the curing time was complete it was determined that the preparation produced a polythiourethane polymer.

DETD In the second MCO polythiourethane example, MCO was weighed into a polyethylene beaker. To the MCO agent was added Luprinate M20S at a ***thiol*** to isocyanate mole ratio of 1.00. To this reaction mixture was added dibutyl tin dilaurate (DBTDL) at a weight percent of 0.125 based upon the total weight of the ingredients. The three-component reaction mixture was then manually stirred with a wooden Popsicle stick. The entire pre-polymer mixture was then poured into a mold for curing and cured using curing profile B. After the curing time was complete it was determined that the preparation produced a polythiourethane polymer.

DETD In the polythiourethane compositions, the feedstock ***thiol*** ester compositions that were used included MSO (mercaptanized soybean oil), MHSO (mercaptohydroxy soybean oil), CMSO (cross-linked mercaptanized soybean oil), castor oil, and MCO (mercaptanized castor oil). The diisocyanates that were used to produce these compositions included MDI (4,4'-methylenebis(phenyl) diisocyanate), HMDI (4,4'-methylenebis(cyclohexyl) diisocyanate, which is also known as hydrogenated MDI), TDI (tolylene 2,4-diisocyanate), HDI (1,6-diisocyanatohexane, which is also known as hexamethylene diisocyanate), and Luprinate.TM. M20S (which is an oligomerized form of MDI and is also referred to as polymeric MDI that is produced by BASF Corporation). The catalysts that were used included DABCO (diazabicyclooctane--di-tertiary amine), DBTDL (dibutyl tin dilaurate--organometallic catalyst), Jeffol.RTM. A-480 (which is a tertiary amine polyol produced by Huntsman Based Chemicals), and BDMA (benzyl dimethylamine).

DETD In the Fertilizer Examples, the following materials were used:

A: Fertilizer particles--granular fertilizer grade urea, SGN 250, commercially available from Agrium;

B1: Mercaptanized soybean oil (an example of MVO discussed above)--Polymercaptan 358, available from Chevron Phillips Chemical Co.;

8.65% ***thiol*** sulfur; 370 equivalent weight; viscosity of 510.6 cSt @ 21.degree. C.;

B2: Mercapto-hydroxy soybean oil (an examples of MHVO discussed above)--A

mercapto-hydroxy soybean oil made by the free radical addition of hydrogen sulfide to epoxidized soybean oil; the mercapto and hydroxy functionalities are equal; 8.335% ***thiol*** sulfur; equivalent weight 192 (including both mercapto and hydroxy functionalities);

B3: Sulfur cross-linked mercaptanized soybean oil (an example of CMVO discussed above)--A sulfur cross-linked mercaptanized soybean oil made by the addition of elemental sulfur to mercaptanized soybean oil; ***thiol*** sulfur content 6.33%; equivalent weight 506;

B4: Sulfur cross-linked mercaptanized soybean oil (an example of CMVO discussed above)--A sulfur cross-linked mercaptanized soybean oil made by the addition of elemental sulfur to mercaptanized soybean oil; ***thiol*** sulfur content 7.64%; equivalent weight 419; cross-linkcross-link

C1: Isocyanate #17--A polymeric MDI, commercially available from BASF Canada, equivalent weight of 133;

C2: Epoxy resin--5 minute epoxy resin, commercially available from ITW Devcon, Danvers, Mass. 01923 USA, equivalent weight 198;

D1: Organic additive--Gulftene C30-HA alpha olefin wax, commercially available from Chevron Phillips Chemical Co., melting point 65.degree. C.-80.degree. C.;

D2: Organic additive--Calwax 170, a microcrystalline wax commercially available from Calwax Corporation;

E: Cross-linking agent--Jeffol A480, commercially available from Huntsman Polyurethanes; equivalent weight of 120; functionality 4.0; viscosity of 4000 cPs @25C;

F1: Amine catalyst: Exp-9, commercially available from Huntsman Polyurethanes; and

F2: Amine catalyst: 1,8-Diazabicyclo[5,4,0]undec-7-ene (DBU), CAS# ***6674-22-2***

DETD Analysis of the ***Thiol*** Containing Esters, Hydroxy ***Thiol*** Containing Esters and Cross-Linked ***Thiol*** Containing Ester

DETD Particular aspects of the ***thiol*** containing esters, hydroxy ***thiol*** containing esters, cross-linked ***thiol*** ester, unsaturated esters and epoxidized unsaturated esters are measured particular analytical techniques. ***Thiol*** sulfur values were obtained using a silver nitrate titration as described in ASTM D3227 or by Raman spectroscopy. Carbon-carbon double bond to ***thiol*** group molar ratio, cyclic sulfide to ***thiol*** group molar ratios were determined by .sup.13C NMR and/or GC analysis of the ***thiol*** containing ester or hydroxy ***thiol*** containing ester side chains.

DETD ***Thiol*** Sulfur Content by Raman Spectroscopy

DETD ***Thiol*** sulfur content was measured by both silver

nitrate titration, ASTM D3227, and/or Raman spectroscopy. The Raman spectroscopy method is practiced by measuring the Raman spectra of the ***thiol*** containing ester, hydroxy ***thiol*** containing ester, cross-linked ***thiol*** ester and comparing the spectra to calibration standards containing known ***thiol*** compounds having known amounts of ***thiol*** groups. Generally, the calibration standard ***thiol*** compound has a similar structure to the ***thiol*** containing esters analyzed.

DETD The ***thiol*** containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester ***thiol*** content were determined by comparing the Raman spectra of the ***thiol*** containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester to calibration standards prepared from mercaptanized methyl oleate diluted in soybean oil to known ***thiol*** sulfur contents. ***Thiol*** sulfur calibration standards were prepared using standards using various known concentration of mercaptanized methyl oleate diluted in soybean oil.

DETD Raman spectra of the calibration standards and the ***thiol*** containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester were measured using a Kaiser Hololab 5000 Process Raman spectrometer, using a 785 nm laser.

Thiol containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester samples and the ***thiol*** sulfur calibration standard Raman spectra were obtained by collecting four 10 second scans which were then processed using Holoreact software.

Thiol sulfur values for the ***thiol*** containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester were then calculated using the ratio of the peak area values of the ***thiol*** SH peak (center: 2575 cm-1; area 2500-2650 cm-1), and the C.dbd.O peak (center--1745 cm-1; area--1700-1800 cm-1) and comparing them to the peak area values for the calibration standards and interpolating the containing esters, hydroxy ***thiol*** containing esters and cross-linked ***thiol*** ester ***thiol*** sulfur contents. Repeatability of the ***thiol*** sulfur values as measured

by Raman spectroscopy have been shown to have a standard deviation of 0.05-0.1 and a % RSD of 0.6-1.5 using 5 samples having a % sulfur content ranging from 3.1-10.6 weight percent as measured over a two month period.

DETD The Raman spectroscopy technique for determining the sulfur content of a containing ester, hydroxy containing ester, and a cross-linked containing ester has been illustrated using a containing ester produced from soybean oil. However, one skilled in the art may adapt and apply the Raman spectroscopy technique for determining the sulfur content of other containing esters, hydroxy containing esters, and a cross-linked containing esters described herein.

DETD C.dbd.C to ***Thiol*** Group and Cyclic Sulfide Group to Tool Group

DETD Molar Ratios by .sup.13C NMR

DETD Carbon-carbon double bond to group molar ratio and cyclic sulfide group to group molar ratios were determined by .sup.13C NMR. containing ester .sup.13C

Varian Mercury spectra were obtained on a Varian Mercury INOVA400 NMR, a Mercury Plus 300 NMR, or equivalent spectrometer (75.5 MHz .sup.13C NMR). Peak areas were determined for the cyclic sulfide carbon atoms, group HS--C carbon atoms and carbon-carbon double bonds carbon atoms using the .sup.13C NMR regions indicated in the table below:

Functional Group	.sup.13C NMR Region	Number of Carbon Atoms/Group
Cyclic Sulfide Carbon Atoms	49-49.5 ppm	2
HS--C Carbon Atoms	40-41.5 ppm	1
C.dbd.C Carbon Atoms	120-140 ppm	2
DETD The containing ester cyclic sulfide to group molar ratio were calculated by dividing the cyclic sulfide carbon atoms .sup.13C NMR peak area by 2 (to account for the 2 carbon atoms per cyclic sulfide group) and dividing the resultant number by the group HS--C carbon atoms .sup.13C NMR peak area.		
The containing ester carbon-carbon double bond to group molar ratio were calculated by dividing the		

C.dbd.C
carbon atoms .sup.13C NMR peak area by 2 (to account for the 2
carbon
atoms per carbon-carbon double bond) and dividing the result
number by
the ***thiol*** group HS--C carbon atoms .sup.13C NMR peak
area
Offset sample .sup.13C NMR's for soybean oil and a ***thiol***
containing ester produced from soybean oil using the disclosed
process
is provided as FIG. 1.
DETD The NMR technique for analyzing the unsaturated ester and the
thiol containing ester produced from an unsaturated
ester have
been illustrated using .sup.13C NMR on soybean oil the
thiol
containing ester produced from soybean oil. However, one skilled
in the
art may adapt and apply either the .sup.13C NMR or .sup.1H NMR
technique
to analyze the unsaturated esters and ***thiol*** containing
ester
produced from the unsaturated ester described herein.
DETD ***Epoxide*** Group to ***Thiol*** Group Molar Ratios by
.sup.13C or .sup.1H NMR
DETD The ***epoxide*** group to ***thiol*** group molar
ratios were
determined using .sup.1H or .sup.13C NMR. Hydroxy ***thiol***
containing ester .sup.1H or .sup.13C NMR spectra were obtained on
a
Varian Mercury INOVA400 NMR, a Varian Mercury Plus 300 NMR, or
equivalent spectrometer (300 MHz .sup.1H NMR-75.5 MHz .sup.13C
NMR).
Peak areas were determined for the ***epoxide*** group and
sulfide
group using the .sup.13C and or .sup.1H regions indicated in the
table
below:

Functional Group	.sup.1H NMR Region	.sup.13C NMR Region	Number of Carbon Atoms/Group	Number of Hydrogen Atoms/Group
Epoxide Group	2.75-3.2 ppm	53.6-56.6 ppm	2	
2 Carbon Atoms HS--C Carbon Atoms	3.2-4 ppm	40-41.5 ppm	1	1
DETD group to	The hydroxy ***thiol*** group molar ratio were calculated by dividing the ***epoxide*** group carbon atoms .sup.1H NMR peak area by 2	containing ester		
(to	account for the 2 hydrogen atoms attached to the ***epoxide***			
group	carbon atoms) and dividing the result number by the ***thiol*** group HS--C carbon atom hydrogens 1C NMR peak area. Similarly,			
the				

to hydroxy ***thiol*** containing ester ***epoxide*** group
 peak ***thiol*** group molar ratio were calculated using ¹³H NMR
 areas.
 DETD The average number of ***epoxide*** group per epoxidized
 methods unsaturated ester molecule can be determined utilizing similar
 group utilizing either the carbonyl group carbon atom or the C--O ester
 carbon atoms .sup.13C NMR peak areas in conjunction with the
 epoxide group .sup.13C NMR peak area. Sample .sup.1H
 NMR's epoxidized soybean oil and a ***thiol*** containing ester
 produced from epoxidized soybean oil 1 are provided in FIG. 2.
 DETD The NMR technique for analyzing the epoxidized unsaturated ester
 and the ***thiol*** containing ester produced from an epoxidized
 unsaturated ester (a hydroxy ***thiol*** containing ester)
 has been illustrated using .sup.1H NMR on epoxidized soybean oil the
 thiol containing ester produced from epoxidized soybean
 oil. However, one skilled in the art may adapt and apply either the
 .sup.1H NMR or .sup.13C NMR technique to analyze the epoxidized
 unsaturated esters and ***thiol*** containing ester produced from the
 epoxidized unsaturated ester described herein.
 DETD Analysis of Unsaturated Esters, Epoxidized Unsaturated Esters,
 Thiol Containing Esters, and Hydroxy ***Thiol***
 Containing Esters by Methanolysis
 DETD Many properties of the unsaturated esters, epoxidized
 unsaturated esters, ***thiol*** containing esters, and hydroxy
 thiol containing ester were and/or can be determined by converting the
 complex ester molecules into their component polyols and carboxylic acid
 methyl esters. The converted esters are then analyzed by gas
 chromatography (GC) and/or gas chromatography/mass spectrometry (GCMS) to
 determine the composition of the complex ester side chains. Properties that are
 or can be determined by the methanolysis followed by GC or GC/MS of the
 carboxylic acid methyl esters include the number of side chain
 that contain ***thiol*** groups, the percent of ***thiol***
 group sulfur, the number of (or average number) of double bonds per
 ester molecule, the molecular weight distribution (or average molecular
 weight) of the ester side chains, The number of (or average
 number of) ***epoxide*** groups per ester molecule, the cyclic sulfide

to ***thiol*** group molar ratio, the carbon-carbon double bond
to ***thiol*** group molar ratio, and the ***epoxide***
group to ***thiol*** group molar ratio, among others.
DETD Depending upon the material being subjected to the methanolysis
 procedure, there are two methanolysis procedures that were
practiced
 upon the unsaturated ester, epoxidized esters, ***thiol***
 containing ester, and hydroxy ***thiol*** containing esters
 described within the experimental section.
DETD Unsaturated esters and ***thiol*** containing ester produced
from
 unsaturated ester were subjected to a hydrogen chloride based
 methanolysis procedure. In the hydrogen chloride methanolysis
procedure,
 a 50 to 100 mg sample of the ***thiol*** containing ester is
 contacted with 3 mL of 3 N methanolic HCl and reacted for 2 hours
a
 50.degree. C. The solution is then allowed to cool and the
neutralized
 with a dilute sodium bicarbonate solution. The solution's organic
 components are then extracted with ethyl ether and analyzed by GC
and/or
 GC/MS. Additional details for the methanolic hydrogen chloride
 methanolysis procedure may be found in the product specification
sheet
 for methanolic HCl, 0.5 N and 3 N as supplied by Supelco.
DETD Epoxidized unsaturated esters and hydroxy ***thiol***
containing
 esters produced from epoxidized unsaturated esters were subjected
to a
 sodium methoxide based methanolysis procedure. The sodium
methoxide
 methanolysis procedure was based upon the procedure disclosed in
U.S.
 Pat. No. 3,991,089. In the sodium methoxide methanolysis
procedure,
 approximately 1 g of the ester was placed in a 50 mL vial with
5.0 mL
 25% sodium methoxide in methanol, and 10 mL methanol. The mixture
was
 shaken for approximately 1 hour at room temperature, during which
time
 the solution became one phase. The mixture was then poured into
25 mL of
 distilled water. Diethyl ether, 25 mL, was added to the solution
and the
 mixture was acidified with 0.5 N HCL to a pH of approximately 5.
The
 organic layer was separated from the aqueous layer using a
separatory
 funnel. The organic layer was washed successively with distilled
water
 (15 mL) and brine solution (15 mL) and then dried over magnesium
 sulfate. The magnesium sulfate was separated from the organic
solution
 by filtration and the solvent removed by rotary evaporation.
DETD FIG. 3 provides a GC/MS trace of a mercaptanized soybean oil

subjected
to the methanolysis procedure and analyzed by GC/MS using a HP-5
30 m.times.0.32 mm id.times.0.25 .mu.m film thickness GC Column.
Table 11 provides the GC/MS trace peak assignments.
TABLE 11

GC/MS Data for Methanolysis of A ***Thiol*** Containing Ester
Produced from
Soybean Oil
GC Retention time Methyl Ester Carboxylic Acid Assignment

21.58	Methyl hexadecanoate
23.66	Methyl (C18 monoene)oate
23.74	Methyl (C18 monoene)oate
23.96	Methyl octadecanoate
26.46	Methyl (C18 Monoene monomercaptan)oate
26.59	Methyl (C18 Monoene monomercaptan)oate
26.66	Methyl (C18 Monoene monomercaptan)oate
26.80	Methyl (C18 monomercaptan)oate
27.31	Methyl (C18 cyclic sulfide)oate
27.44	Methyl (C18 cyclic sulfide)oate
29.04	Methyl (C18 dimercaptan)oate
29.15	Methyl (C18 dimercaptan)oate
29.37	Methyl (C18 monoene dimercaptan)oate
29.46	Methyl (C18 monoene dimercaptan)oate
30.50	Methyl (C18 di (cyclic sulfide))oate

Peaks at 29.37 or 29.46 could also contain Methyl (C18 cyclic sulfide monomercaptan)oate isomers as part of those peaks.

DETD FIG. 5 provides a GC/MS trace of an epoxidized soybean oil contacted with hydrogen sulfide (a hydroxy ***thiol*** containing ester) subjected to the methanolysis procedure and analyzed by GC/MS using a HP-5 30 m.times.0.32 mm id.times.0.25 .mu.m film thickness GC Column.
Table 13 provides the GC/MS trace peak assignments.
TABLE 13

GC/MS Data for Methanolysis of a Hydroxy ***Thiol*** Containing Ester
Produced from Epoxidized Soybean Oil
GC
Retention time Methyl Ester Carboxylic Acid Assignment

16.09	Methyl hexadecanoate
17.68	Methyl octadecanoate
18.94	Methyl (C18 monoepoxide)oate
19.94	Methyl (C18 diepoxide)oate
20.14	Methyl (C18 diepoxide)oate
20.75	Methyl (C18 monohydroxy monothiol)oate
21-21.5	Methyl (C18 triepoxide)oate
22.82	Methyl (C18 dihydroxy dithiol)oate
22.90	Methyl (C18 monoepoxide monohydroxy monothiol)oate

27-27.5 Unidentified mixture of C18 sulfur containing methyl esters

DETD The methanolysis procedure and GC/MS procedure has been illustrate using soybean oil, epoxidized soybean oil, and the ***thiol*** containing products derived from soybean oil and epoxidized soybean oil.

However, one skilled in the art can easily adapt the procedures to the analysis of other unsaturated esters, epoxidized unsaturated ester, and the ***thiol*** containing products derived from the unsaturated esters and epoxidized unsaturated esters as described herein.

DETD The polythiourethane produced from the ***thiol*** containing esters, hydroxy ***thiol*** containing esters, and cross linked ***thiol*** containing ester were analyzed using ASTM E1545-95A and E228-95 to provide the glass transition temperatures and the coefficients of thermal expansion. Shore hardness of the polythiourethanes were determined using ASTM D2240-02A. The polythiourethane were also subject to a subjective analysis classifying the polythiourethanes as hard, flexible, rubbery, rigid, tough, brittle, and other characteristics.

CLM What is claimed is:

1. A cross-linked ***thiol*** ester composition comprising ***thiol*** ester oligomers having at least two ***thiol*** ester monomers connected by a polysulfide linkage having a structure --S.sub.Q--, wherein Q is greater than 1.

CLM What is claimed is:

2. The cross-linked ***thiol*** ester composition of claim 1, wherein the ***thiol*** ester oligomers have at least three ***thiol*** ester monomers connected by polysulfide linkages.

CLM What is claimed is:

3. The cross-linked ***thiol*** ester composition of claim 1, wherein the ***thiol*** ester oligomers have from 3 to 20 ***thiol*** ester monomers connected by polysulfide linkages.

CLM What is claimed is:

4. The cross-linked ***thiol*** ester composition of claim 1, wherein the crosslinked ***thiol*** ester composition comprises ***thiol*** ester monomers and ***thiol*** ester oligomers.

CLM What is claimed is:

5. The cross-linked ***thiol*** ester composition of claim 4, wherein the ***thiol*** ester monomers and ***thiol*** ester oligomers have a total ***thiol*** sulfur content from 0.5 to 8 weight percent.

CLM What is claimed is:
6. The cross-linked ***thiol*** ester composition of claim 4,
wherein the combined ***thiol*** ester monomers and
thiol
ester oligomers have an average molecular weight greater than
2000.

CLM What is claimed is:
7. The cross-linked ***thiol*** ester composition of claim 4,
wherein the ***thiol*** ester monomers and ***thiol***
ester
oligomers have an average molecular weight from 2000 to 20,000.

CLM What is claimed is:
8. The cross-linked ***thiol*** ester composition of claim 4,
wherein the ***thiol*** ester monomers and ***thiol***
ester
oligomers have a total sulfur content ranging from 8 to 15 weight
percent.

CLM What is claimed is:
9. A cross-linked ***thiol*** ester composition produced by
the
process comprising the steps of: a) contacting a ***thiol***
ester
composition with an oxidizing agent; and b) reacting the
thiol
ester and the oxidizing agent to form ***thiol*** ester
oligomers
having at least two ***thiol*** ester monomers connected by a
polysulfide linkage having a structure --S.sub.Q--, wherein Q is
greater
than 1.

CLM What is claimed is:
10. A process to produce a cross-linked ***thiol*** ester
composition comprising: a) contacting a ***thiol*** ester
composition with an oxidizing agent; and b) reacting the
thiol
ester and the oxidizing agent to form ***thiol*** ester
oligomers
having at least two ***thiol*** ester monomers connected by a
polysulfide linkage having a structure --S.sub.Q--, wherein Q is
greater
than 1.

CLM What is claimed is:
13. The process of claim 10, wherein the ***thiol*** ester is
a
hydroxy ***thiol*** ester.

CLM What is claimed is:
14. The process of claim 10, wherein a weight ratio of elemental
sulfur
to ***thiol*** sulfur in the ***thiol*** ester molecules
ranges
from 0.5 to 32.

CLM What is claimed is:
15. The process of claim 10, wherein step of the reacting the

thiol ester and the oxidizing agent is performed at a temperature ranging from 25.degree. C. to 150.degree. C.

CLM What is claimed is:
16. The process of claim 10, wherein residual hydrogen sulfide is stripped from the cross-linked ***thiol*** ester composition produced.

CLM What is claimed is:
17. The process of claim 12, wherein the reaction of the ***thiol*** ester and the elemental sulfur is catalyzed.

IT 102-85-2, Tri-n-butylphosphite ***6674-22-2*** ,
1,8-Diazabicyclo[5.4.0]undec-7-ene
(activator; thiol ester compns. prepd. by reacting H2S with unsatd. esters, such as soybean oil for manuf. monomers for prodn. of polythiourethanes for fertilizers)
ACCESSION NUMBER: 2005:227538 USPATFULL <<LOGINID:20090306>>
TITLE: ***Thiol*** ester compositions and processes for

making and using same
INVENTOR(S): Byers, Jim D., Bartlesville, OK, UNITED STATES
Refvik, Mitchell D., Bartlesville, OK, UNITED STATES
STATES
PATENT ASSIGNEE(S): Brown, Chad D., Bartlesville, OK, UNITED STATES
Chevron Phillips Chemical Company LP (U.S. corporation)

	NUMBER	KIND	DATE
PATENT INFORMATION:	US 20050197390	A1	20050908
APPLICATION INFO.:	US 2005-59792	A1	20050217 (11)

	NUMBER	DATE
PRIORITY INFORMATION:	US 2004-545260P	20040217 (60)
	US 2004-561614P	20040413 (60)
	US 2004-561685P	20040413 (60)
	US 2004-561855P	20040413 (60)
DOCUMENT TYPE:	Utility	
FILE SEGMENT:	APPLICATION	
LEGAL REPRESENTATIVE:	CHEVRON PHILLIPS CHEMICAL COMPANY LP, LAW	
DEPARTMENT -	IP, P.O BOX 4910, THE WOODLANDS, TX, 77387-4910,	
US		
NUMBER OF CLAIMS:	18	
EXEMPLARY CLAIM:	1	
NUMBER OF DRAWINGS:	14 Drawing Page(s)	
LINE COUNT:	6310	
CAS INDEXING IS AVAILABLE FOR THIS PATENT.		

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